Surveillance, Monitoring and Management of North Atlantic Right Whales, *Eubalaena glacialis*, in Cape Cod Bay, Massachusetts: January to Mid-May, 1999.

Final Report

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Contract No. SCFWE3000-8365027

October 30, 1999

Executive Summary

The Cape Cod Bay Critical Habitat Area and adjacent waters are an important winter and spring feeding area for the North Atlantic Right Whale, *Eubalaena glacialis*. Right whales, first recorded in Cape Cod Bay in the 1600s, have been the subject of research in this area since 1984, and an intensive surveillance and monitoring program for the last two years (1998 and 1999) as part of the Massachusetts Division of Marine Fisheries Right Whale Conservation Plan. In 1999, the right whale surveillance team was in position in Cape Cod Bay for 135 days. Aerial surveys were conducted on 36 days in Cape Cod Bay and adjacent waters between 1 January and 15 May 1999, with one pre-season flight on 13 December 1998. There were a total of 28 vessel days in Cape Cod Bay in 1999. Habitat sampling were carried out on board the R/V *Shearwater* on 22 days (including one pre-season sampling trip on 19 December 1998) and 14 of these occurred on the same day as an aerial survey.

There were a total of 308 photographed sightings of right whales collected during 36 aerial survey days and 135 photographed sightings of right whales collected during 28 vessel days in Cape Cod Bay. All sightings were reported daily to the National Marine Fisheries Service Ship Advisory System. An additional seven photographed sightings of right whales were obtained during two aerial surveys of the Great South Channel (11 and 12 May) after right whales had departed from Cape Cod Bay. Also included in the photo-analysis for this report were seven photographed sightings of right whales obtained during a flight in the Great South Channel in support of a disentanglement effort on 23 May. Thus there were a total of 457 photographed right whale sightings analyzed for this report.

To date, of those 457 photographed sightings, 412 (90%) have been matched to a total of 91 individual right whales. Of these 91 right whales, 86 individuals were seen in Cape Cod Bay and five were unique to the Great South Channel. Of the 86 right whales identified in Cape Cod Bay and matched to the catalogue, nine of those right whales had not previously been identified in the waters around Massachusetts prior to 1999 including: #s 1716, 1812, 1981, 2710, 2740, 2750 and three (3) new whales that do not have a catalogue number yet: 99-5, 99-42 and 99-183. Two of these new whales, 99-42 and 99-183 have only ever been seen in Cape Cod Bay. A skin biopsy sample was also obtained from each of the three new whales and will be used to establish their family relationships. There were no mother calf pairs seen in Cape cod Bay in 1999, only the third such year (other years were 1995 and 1998) since 1982.

In 1999, between 1 January and mid-May, there were three reports of entangled right whales, one was an observed temporary entanglement, one was a false report and the third was an unconfirmed report from an unknown location. There was one mortality; on 20 April, and adult female #1014, nicknamed Staccato, was found floating dead in Cape Cod Bay. She had previously been sighted eight times during the field season, the last sighting of her alive was on 15 April. A necropsy was performed and the cause of death was blunt trauma, likely the result of a collision with a ship.

Research efforts in Cape Cod Bay in 1998 and 1999 have identified 122 different right whales, 42% of the catalogued population. The Cape Cod Bay Critical Habitat Area is clearly established as an important area for right whales from early December through mid-May.

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Abbreviations used in the text: **DMF** - Massachusetts Division of Marine Fisheries; **CCS** - Center for Coastal Studies; **NEAq** - New England Aquarium; **URI** - University of Rhode Island; **USCG** - United States Coast Guard; **NMFS** - National Marine Fisheries Service; **NEFSC** - Northeast Fisheries Science Center; **NER** - Northeast Region; **SAS** - Ship Advisory System; **WHOI** - Woods Hole Oceanographic Institution.

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Introduction

The northern right whale, *Eubalaena glacialis*, one of the rarest large whales in the world, is listed as "endangered" under the Endangered Species Act (ESA) of 1972. Estimates indicate that no more than 350 remain in the western North Atlantic (CeTAP 1982, Brownell *et al.* 1986, Kraus *et al.* 1988, NMFS 1991, Knowlton *et al.* 1994) despite international protection from commercial hunting since 1937. Scientists and conservationists have long been concerned about the status of the North Atlantic right whale population and its slow rate of growth (about 2.5% per year in the 1980s, Knowlton *et al.* 1994), but recent analyses showing a decrease in the reproductive rate, an increase in the calving interval (Kraus *et al.* In press), and a decline in the survival rate (Caswell *et al.* 1999) suggest we should view the present situation in the 1990s with greater concern. The apparent failure of the population to recover has been attributed to a variety of factors including mortality from collisions with ships and entanglements in fixed fishing gear (Kraus 1990, Kenney and Kraus 1993, Knowlton and Kraus In press). There have been 45 right whale deaths reliably documented since 1970. Of those 45, 17 right whale fatalities were due to ship strikes, and three were the result of entanglement in fixed fishing gear (Knowlton and Kraus In press, NEAq unpublished data). Ship collisions kill more right whales than any other documented causes of mortality and one half of the ship collisions mortalities have been documented in the 1990s.

Right whales are known to occur in Cape Cod Bay, Massachusetts, and adjacent waters* in all months of the year, with the peak of occurrence from February through April (Schevill *et al.* 1986, Winn *et al.* 1986, Hamilton and Mayo 1990, Payne *et al.* 1990, Brown 1994). The Cape Cod Bay ecosystem, one of five known seasonal high-use habitat areas for this species in the western North Atlantic, was federally designated a Critical Habitat for the North Atlantic right whale in 1994 (Federal Register 59 FR 28793, Figure 1) in recognition of its seasonal importance as a feeding area and as a nursery area for cows and calves (Kraus and Kenney 1991), including a number of cows that are rarely seen in the other three northern habitat areas (Knowlton *et al.* 1992, Brown 1994). Right whales are slow moving (particularly when accompanied by a calf), they are difficult to see when feeding just below the surface, and do not always avoid approaching vessels, especially when socializing or feeding near the surface. These factors, set against the moderate level of ship traffic in the region, make the right whale vulnerable to collisions with vessels in Massachusetts waters. Knowlton and Kraus (in press) have documented two right whales that have been killed by ships near this area, one in 1986 (found off Provincetown), the second in 1996 (found near Wellfleet). This number, however, is the minimum count because not all carcasses are found and recovered.

Right whales are also at risk of entanglement in fixed fishing gear in the area. Some fishing activity is either prohibited (gill nets) or use of modified gear is required in the Cape Cod Bay Critical Habitat area (sinking ground line between lobster pots, at least two pots per vertical line, twin orange flag markers on buoy stick and a 500lb break away link at the buoy, 322 CMR 12.05 Critical Habitat gear restrictions during January 1 to May 15). Most of the fixed fishing gear in the Cape Cod Critical Habitat Area is located in the northern margins along tracklines one, two and three (Table 1, Figure 1) in depths greater than 30 fathoms. There is fixed fishing gear set to the west of the western margin of the Critical Habitat, an area where right whales have been reported opportunistically in the past

* Adjacent waters includes the federal waters of the Cape Cod Bay Critical Habitat and those waters over- and adjacent to-Stellwagen Bank in Massachusetts Bay (e.g. Stellwagen Basin), as well as waters east of Cape Cod.

(Brown and Marx 1998).

Photographic identifications of right whales in Cape Cod Bay date from 1959 to the present (Hamilton *et al*, 1997, Brown and Marx 1998), however, whaling records provide evidence of right whales in this area from at least the early 1600s. Over the last fifteen years, about 60% of the entire catalogued population of right whales are known to have used Cape Cod Bay and adjacent waters at some time during their lives (CCS, and NEAq, unpublished data). These photographic data have primarily been collected during: twice weekly aerial surveillance flights and weekly vessel-based habitat studies from January to mid-May in 1998 (Brown and Marx 1998); weekly vessel surveillance and limited aerial surveys in the winter and spring in 1997 (Hamilton *et al.* 1997, Mayo 1997); annual studies on foraging of right whales in the winter and spring since 1984 (Mayo and Marx, 1990); by researchers on whale watching vessels from April to October until 1996. The latter platform, which yielded many valuable sightings of right whales (including some rarely seen mothers with newborns) and reports of entanglements (NEAq unpublished data) is no longer available due to a 500 yard exclusion zone around right whales for non-permitted vessels.

While the use of the Cape Cod Bay ecosystem by right whales has occurred for hundreds of years, human activities have only impacted the area relatively recently. In order to gain a better understanding of both the spatial and temporal distribution of individually identified right whales in Cape Cod Bay, an extensive research program was undertaken in the winter and spring of 1998 (Brown and Marx 1998) and 1999 with support from the Massachusetts Division of Marine Fisheries, and the Massachusetts Environmental Trust. This research directly addressed concerns identified by: the Right Whale Conservation Plan submitted by the Commonwealth of Massachusetts to federal courts in 1996; the Northeast Implementation Team; and supported goals in the federal Large Whale Take Reduction Plan; the Right Whale Recovery Plan (NMFS 1991); and the ESA. The objectives of the 1999 surveillance, monitoring and management program were:

I) To document the right whales in the Cape Cod Bay Right Whale Critical Habitat area and adjacent waters from January through mid-May, 1999, using photo-identification techniques to identify individual whales. These data provide information on the age, sex, reproduction, distribution, abundance and patterns of habitat use (residency) of right whales in Cape Cod Bay and help refine long-term, range-wide analyses on presumed mortality, incidence of scarring and demographics. Photographic and sighting data were integrated into the right whale photo-identification catalogue at the New England Aquarium and the sighting database at the University of Rhode Island.

II) To provide sighting data to the National Marine Fisheries Ship Advisory System. Data on the sighting location of right whales were reported promptly to NMFS/SAS at the completion of each survey. The goal was to ultimately reduce the probability that right whales will be killed by collisions with large vessels by providing near "real-time" sighting data within Massachusetts waters to port authorities, commercial and military vessels, and other maritime operations.

III) To monitor the right whales in the study area for evidence of entanglement. Each right whale encountered was examined visually for any evidence of attached gear. The disentanglement team was on standby for immediate dispatch in the event an entangled whale was reported. This effort increased the opportunity to spot an entangled right

whale, especially those carrying gear from outside critical habitat since there is very little fixed gear fishing during the winter months.

IV) To describe the distribution and abundance of any other marine mammals and shipping activity in Cape Cod Bay and adjacent waters from January through mid-May, 1999.

V) To collect oceanographic information on weekly vessel cruises, from January to mid-May, 1999, designed to develop an understanding of the characteristics of the habitat to which right whales respond. These oceanographic data, combined with data from past habitat studies in Cape Cod Bay by the Center for Coastal Studies, provide additional information on the conditions which are believed to cue the movements and activities of right whales in Cape Cod Bay and adjacent waters.

Here we report on the results of the research activities in 1999 as described in the above objectives I through IV. All photographs of right whales collected during oceanographic sampling (objective V) have been incorporated with the analysis of aerial photographs. The data and results of the oceanographic sampling program are contained in Mayo, Lyman and Finzi (1999) Monitoring the habitat of the North Atlantic right whale in Cape Cod Bay in 1999: An evaluation of the influence of food resources on whale distribution and occurrence.

Methods

I) Aerial Surveys

Aerial surveys were conducted on December 13, 1998 and twice weekly from January through mid-May in the Cape Cod Bay Critical Habitat and adjacent waters. The aerial survey protocol for Cape Cod Bay as described in Kraus *et al* (1997) was adopted with some modifications (Brown and Marx 1998). Fifteen tracklines were flown latitudinally (east-west) at 1.5 nautical mile (nm) intervals from the mainland to the Cape Cod shoreline (Figure 1). An additional trackline 25 nm in length that approximately paralleled the eastern side of Cape Cod was flown at a distance of about three nm from shore (Figure 1). The east-west flight pattern in Cape Cod Bay was chosen for scientific and safety reasons. In these latitudes, winter aerial surveys are hampered by low sun angles in the early and latter portions of a survey day and glare is a significant factor in sightability of marine mammals. On east-west tracklines, although glare was a factor in one of the forward quadrants, there was always a section of the survey swath that could be observed without being compromised by glare. It was also safer to have the aerial survey tracklines begin and end near land. A total of 318.2 nm of 'on-trackline' miles were flown during each completed survey (Table 1). On-trackline miles are those miles flown while surveying due east or due west in Cape Cod Bay and along the eastern side of Cape Cod, but excludes all miles flown between tracklines or while circling.

The surveys were flown under VFR (visual flight rules) conditions up to and including Beaufort sea state four. Surveys were aborted in Beaufort sea state five and/or when visibility decreased below two miles. All aerial surveys were conducted in a Cessna 337 Skymaster (5382S), a twin engine high-wing aircraft. The aircraft was equipped with GPS (global positioning system) and LORAN-C navigation systems, full IFR (instrument flight rules) instrumentation, marine VHF radio with external antenna, a life raft, four survival suits, signal flares, a medical kit, a waterproof VHF radio, a portable EPIRB, and an aircraft mounted ELT (emergency locator transmitter). All occupants wore aircraft approved PFDs (personal floatation device) during the entire flight.

Surveys were conducted at a standard altitude of 750 feet (229 meters) and a ground speed of approximately 100 knots, using methodology developed by CeTAP (Scott and Gilbert 1982, CeTAP 1982). The survey team consisted of a pilot, data recorder, and two observers positioned on each side of the aircraft in the rear seats. The two rear seat observers scanned the water surface from 0° - 90°, out to at least two nautical miles and reported sightings when they were abeam of the aircraft. In order to maintain a standardized sighting effort, the pilot and data recorder were instructed not to alert the observers to any sightings until after it had been passed by the aircraft and clearly missed by the observers.

All sightings of marine animals except birds were recorded. Sightings identified as species other than right whales were counted, logged and passed without breaking the transect and circling in order to maximize flight time available for investigating right whale sightings. Sightings of all vessels in the area were recorded by location and type. At sightings identified as right whales, as well as sightings of large whales which were not immediately identified by species, the aircraft broke track at right angles to the sighting and circled for photographs. Photographs were obtained of as many individual right whales within a given aggregation as possible. For each right whale, behavior and interaction with any nearby vessels was noted. In a few instances, when right whales were spotted from the plane in close vicinity to R/V *Shearwater*, the vessel was contacted from the plane and photographs were taken from the vessel so that the plane could devote more time to surveying. The right angle distance of each sighting from the flight track was determined from GPS positions.

At the conclusion of photographic work on each sighting, the aircraft returned to the trackline at the point of departure using the GPS right angle sighting position recorded in the log. These methods conform to research protocols followed by the North Atlantic Right Whale Consortium (CCS, NEAq, URI, and WHOI) and approved by the U.S. NMFS. Trackline and sighting data from the daily logs were entered into the Right Whale Initiative DBase program designed for compatibility with the Right Whale Consortium database. Copies of the daily logs from the aerial surveys are on file at CCS.

II) Vessel Surveys

CCS maintains two research vessels: the 40' (12m) twin diesel engine R/V *Shearwater* and the 28' (8.5m) twin outboard engine R/V *Gannet.* The R/V *Shearwater* has been used successfully for photo-identification and oceanographic sampling in the winter surveillance program in Cape Cod Bay, 1997 and 1998. The R/V *Gannet* was used for additional photo-identification and biopsy sampling.

Dr. Charles Mayo (CCS) and research assistant Juliette Finzi advised and assisted in the oceanographic sampling at no cost to this contract. (The collection and analysis of the oceanographic samplings outlined below was made possible by a grant to Dr. Mayo by the Massachusetts Environmental Trust. DMF supported the vessel time. See Mayo, Lyman and Finzi, 1999, for details on data collection and results in 1999.) The R/V *Shearwater* was equipped with oceanographic sampling equipment including a CTD (conductivity, temperature, depth), plankton nets, surface plankton pump, and flow meter. These basic oceanographic data will be used to develop an understanding of the characteristics of the habitat to which the right whales respond.

Although the primary objective of these vessel cruises was habitat sampling, photographs were collected opportunistically of any right whales in the vicinity during sampling and on transits to and from sampling sites. Photographs of right whales obtained during habitat studies were integrated with the photographs collected during aerial surveillance and included in analyses of residency, capture rates, demographics, and life history. Sightings data from the vessel daily logs were entered into the Right Whale Initiative DBase program.

CCS is the only institution on the U.S. East Coast with federal authorization from NMFS to perform disentanglements of large whales, and in 1996 the Center developed a Rapid Response Rescue Program with the US Coast Guard to disentangle whales at sea. In the event that an entangled whale was seen during aerial surveys, CCS was to be contacted from the aircraft and the vessel dispatched immediately to assess the situation and proceed with disentanglement protocols. During vessel surveys in which the R/V *Shearwater* was used, the equipment required for first response to a disentanglement was on board at all times.

Additional vessel trips were conducted using R/V *Gannet* to provide supplemental photo-identification and collect biopsy samples (see below). Systematic north-south tracklines were placed over Cape Cod Bay. Surveys on the R/V *Gannet* were conducted at a speed of 12 knots, in sea conditions with visibility of greater than two nm and sea state of Beaufort four or less. The team consisted of three or four experienced right whale researchers. Positions included a helmsperson/data recorder and two observers on watch. Watch positions were rotated as required to reduce fatigue and exposure to cold. The two observers were positioned at the bow and each one scanned the water surface out from the bow, to the port and starboard respectively, to a perpendicular distance of three nm. All sightings of marine animals (except birds) were counted and recorded. The location of each sighting was determined using a GPS navigation system.

III) Notification of Agencies

As soon as possible following the completion of each aerial survey and vessel trip, the number of right whales seen and the location of these sightings was called into the NMFS Ship Advisory System for dissemination to the appropriate agencies and mariners. In order to provide the most thorough information possible, prior to calling in to the NMFS/SAS, any other whale research vessels operating in Cape Cod Bay and adjacent waters were contacted, and their additional sightings were added to the report if from an area not already included in the CCS report. A daily summary of the location and number of right whale sightings was faxed to DMF and to the NMFS/SAS coordinator in Woods Hole, MA.

IV) Photographic Methods

i) Identification Photographs

During aerial and shipboard surveys, photographs were taken on Kodak Kodachrome 200 color slide film, using hand-held 35-mm cameras equipped with 300-mm telephoto lenses and motor drives. From the air, photographers attempted to obtain good oblique photographs of the entire rostral callosity pattern of every right whale and any other scars or markings that are obvious. From the boat, photographers attempted to collect good perpendicular photographs of both sides of the head, the body and the flukes. The data recorder on both platforms was responsible for keeping a written record of the roll and frame numbers used by each observer in the daily log.

ii) Photo-analysis and Matching

Photographs of right whale callosity patterns are used as a basis for identification and cataloguing of individuals, following methods developed by Payne *et al* (1983) and Kraus *et al* (1986). The cataloguing of individually identified animals is based on using high quality photographs of distinctive callosity patterns (raised patches of roughened skin on the top and sides of the head), ventral pigmentation, lip ridges, and scars (Kraus *et al* 1986). The catalogue has been curated by NEAq since 1980 and to the best of their knowledge, all photographs of right whales taken in the North Atlantic since 1935 have been included in NEAq's files. This catalogue allows scientists to enumerate the population, (there are currently about 14,000 sightings of 392 individual right whales of which 291 are thought to be alive, as of December 1998, A. Knowlton, NEAq, pers comm) and, from resightings of known individuals, to monitor the animals' reproductive status, births, deaths, scarring, distribution and migrations.

Photographs taken during the 1999 Cape Cod Bay field effort were separated into individuals and inter-matched within the season. To match different sightings of the same whale, composite drawings and photographs of the callosity patterns of individual right whales are compared to a limited subset of the catalogue that includes animals with a similar appearance. For whales that look alike in the first sort, the original photographs of all probable matches are examined for callosity similarities and supplementary features, including scars, pigmentation, lip crenulations, and morphometric ratios. A match between different sightings is considered positive when the callosity pattern and at least one other feature can be independently matched by at least two experienced researchers (Kraus *et al* 1986). Exceptions to this multiple identifying feature requirement include whales which have unusual callosity patterns, large scars or birthmarks, or deformities so unique that matches from clear photographs can be based on only one feature. Preliminary photo-analysis and inter-matching was carried out at CCS, with matches confirmed using original photographs catalogued and archived at NEAq. All matches to the catalogue were integrated into the right whale database at NEAq.

iii) Photographic Data Archiving

Upon completion of the matching process, all slides will be returned to CCS and incorporated into our own catalogue of identified right whales to update existing files. NEAq will archive copies of photographs representing each sighting taken during the course of this work, in archival quality slide sheets. Copies of photographs of individuals that are better than existing records, and photographs of newly identified whales, will be included in the NEAq master files as "type specimens" for future reference. The master files are maintained in fireproof safes at NEAq and are catalogued by a numbering system. All catalogue files are available for inspection and on-site use by contributors and collaborators.

V) Collection of Biopsy Samples

Techniques for the collection of skin and blubber biopsy samples from individually identified right whales are well established (Brown *et al* 1991). All biopsy sampling efforts were carried out in conjunction with photo-identification efforts (see above). Immediately after adequate photographs for individual identification were obtained, the boat approached the whale for a biopsy attempt. A slow parallel approach, similar to that used to obtain identifying photographs, has been shown to cause minimal disturbance to the whale (Brown *et al* 1991). Cylindrical biopsy tips, made of stainless steel were used. They have a flared rim with a stop collar to prevent deeper penetration. The stop collar also ensures rebound or release from the whale. Biopsy tips were attached to an arrow and sterilized

prior to sampling to eliminate risk of infection. Right whales were darted at a range of about 5-15 meters (~15-50') using a crossbow with a draw weight of 68kg (150 lbs). Arrows were retrieved either by an attached line or through the use of floatation collars. Tissue samples were extracted from the dart using sterile forceps, the skin portion was diced and placed immediately in a sterile, labeled tube, half filled with a preservative solution of saturated salt and 20% DMSO (dimethylsulfoxide). Each right whale encountered on a particular day received a field identification number (e.g. "A" 30 AUG 97), which is used to identify the sample until the whale is matched to a specific individual in the right whale catalogue. Upon return to shore, samples were stored in a refrigerator until shipped to the laboratory at McMaster University (Hamilton, Ontario) to be incorporated into ongoing genetic analyses funded by NMFS. Occasionally, there was a portion of blubber attached to the skin biopsy. The blubber portion was halved with a scalpel, one section was fixed in formalin and the other was frozen in a chemically treated glass vial. These samples were sent to Dr. Michael Moore at WHOI to be integrated with his on-going study on toxin exposure.

VI) Data Management, Analysis, and Interpretation

i) Data Management

Aerial survey data and sightings data from vessel trips were transcribed from standardized field forms and recorded in computerized DBase files for each of the daily surveys in on-site computers. Copies of the daily logs and computerized data files have been sent to URI for entry into the Right Whale Consortium database. Data are proofed twice, once in the field from printouts made immediately after data-entry was completed, and the second time after they are processed at URI.

ii) Data Analysis and Interpretation

All sightings have been incorporated into the right whale catalogue and Consortium database to be integrated with existing data on life histories for each individual identified. Integration of the sightings data collected during these surveys with previously collected data were used to describe the number, age, sex, and reproductive status of the right whales using the Cape Cod Bay habitat area in 1999. The transect data from the aircraft were charted to establish patterns of distribution and assess the seasonal and spatial residency patterns of the Critical Habitat and adjacent waters. The data on vessel locations were charted and compared with the locations of right whales to assess the level of overlap between right whales and vessels in the area. The exact location of fishing activity was not recorded during the aerial surveys, rather the trackline and beginning and end of the fixed gear was noted. Following discussions between the contractor and state biologist Dan McKiernan, it was determined that the counting and recording of fishing activity, that was already documented by other agencies, would take away observer effort from obtaining marine mammal sightings and identification photographs of right whales.

From the individual identifications of right whales obtained during this study, we examined the capture rate, residency and number of days between first and last sighting in Cape Cod Bay. An analysis of the age and sex composition of the winter and spring population was carried out using data from all CCS surveys to assess demographics and habitat use patterns. Right whales, first identified as calves, ranging in age from one to eight years of age were classified as juveniles, individuals age nine or older were classified as adults. Whales that were not first sighted as calves were classified as unknown age for the first eight years of their sighting history and as adults thereafter. All females who have calved are classified as adult. Sexes were assigned based on one of three methods: 1)

direct observation of the genital area; 2) by association with a calf; 3) by the testing of biopsy samples with a sex specific DNA marker (Brown *et al* 1994).

Results

Aerial Surveys

In 1999, the right whale surveillance team was in position in Cape Cod Bay for 135 days from 1 January through 15 May. There were a total of 38 aerial surveys conducted, 36 of these flights were in the Cape Cod Bay Critical Habitat Area (Figures 2-10, Table 2). There were also two late season flights in the Great South Channel (Figure 7, Table 2) after the departure of right whales from Cape Cod Bay. The tally of 36 flights in Cape Cod Bay also includes a pre-season aerial survey on 13 December 1998 to verify reports of an earlier than expected arrival of right whales into Cape Cod Bay. Five right whales were identified on that survey (Figure 2a and Table 2). On three survey days in the latter part of the season, following the completion of the Cape Cod Bay tracklines, the flight crew surveyed in adjacent waters (including two flights on Stellwagen Basin and one flight on Wildcat Knoll) encountering a single right whale in Stellwagen Basin (Figure 6).

The systematic pre-set tracklines in the Cape Cod Bay Critical Habitat Area (Figure 1, Table 1) were surveyed on average in approximately 4 hours and 30 minutes for those surveys that were not aborted due to an increase in wind speed, sea state (above Beaufort 4) or decrease in sighting conditions (to visibility less than two miles). Surveys ranged in duration from about three and a half hours to six and a half hours depending on the number of right whales encountered and the amount of circling required to obtain photographs (Table 2). The turn at the end of each trackline was initiated and completed about 1.5 nm from shore to maximize the opportunity to observe any whales near shore. The two flights in the Great South Channel (11 and 12 May) were conducted in coordination with the National Marine Fisheries Service using the tracklines laid out for the SCOPEX project (South Channel Ocean Productivity Experiment, Kenney *et al.* 1995).

The DMF provided state biologists to fill one of the observer positions on most flights during the season. These biologists were trained in aerial observation techniques for marine mammals, aerial photography techniques for right whales and data collection. The following roster provides the number of flights and accumulated hours during the season for each observer. These researchers could be called upon to verify and document an out-of-season (mid-May to December) right whale event.

State biologist	Number of flights	Hours flown
K. Creighton	3	14.8
B. Hoffman	8	25.6
R. Johnston	12	54.6
J. King	3	11.8
D. McKiernan	6	24.6
Total	32	131.4

Shipboard Surveys

There were a total of 28 vessel days in Cape Cod Bay in 1999 (Table 3). Shipboard surveys for habitat sampling were carried out on board the R/V *Shearwater* on 22 days (including one pre-season sampling trip on 19 December 1998) and 14 of these occurred on the same day as an aerial

survey. There was one additional cruise on the *Shearwater* on 26 January to investigate a possible entangled whale (see section on Human Impacts below). The primary purpose of these habitat sampling cruises was to collect oceanographic data in the Cape Cod Bay Critical Habitat area weekly for 19 weeks. The results and discussion of the oceanographic sampling and an evaluation of the influence of food resources on whale distribution and occurrence are contained in the attached report (Mayo, Lyman, and Finzi 1999).

In addition to their primary objective of habitat sampling, the research team on board the *Shearwater* recorded all marine mammals observed and collected identification photographs of right whales as the opportunity arose (Table 3). These photos have been compared to the ones obtained from the aircraft and were taken through the same matching process as detailed above.

The R/V *Gannet* was used on four days to provide additional photo-identification effort in Cape Cod Bay, collect biopsy samples from individual right whales and verify sightings of right whales reported opportunistically from the beach between Long Point and Race Point or by boaters in Provincetown Harbor. The R/V *Gannet* was also used to respond to the report of a dead right whale in Cape Cod Bay on 20 April (see section on Human Impacts below). An additional biopsy sampling trip was conducted with Dr. Michael Moore of the Woods Hole Oceanographic Institution aboard the M/V *Hannah T* (Table 3).

Sightings and Photo-identifications

There were a total of 308 photographed sightings of right whales collected during 36 aerial survey days and 135 photographed sightings of right whales collected during 28 vessel days in Cape Cod Bay (Tables 2 and 3). An additional seven (7) photographed sightings of right whales were obtained during two aerial surveys of the Great South Channel (11 and 12 May). Also included in the photo-analysis for this report were seven (7) photographed sightings of right whales obtained during a flight in the Great South Channel in support of a disentanglement effort on 23 May. Thus there were a total of 457 (308 + 135 + 7 + 7) photographed right whale sightings analysed for this report. To date, of those 457 sightings, 412 (90%) have been matched to a total of 91 individual right whales whose identification has been confirmed by NEAq researchers (Appendix I). Of these 91 right whales, 86 individuals were seen in Cape Cod Bay and five were unique to the Great South Channel (Appendices I and II). Of the remaining 45 photographed sightings, all were from the Cape Cod Bay Critical Habitat area, 15 (3% of the total) of those have not yet been identified but these photographs do fit the criteria for matching and at this time are thought to represent another five individuals. These photographs are either of low quality or the whale is only partially photographed and may only be matched if we collect other photographs of those whales in the future. These photographs will be reexamined for possible matches as more photos are added to the catalogue. The final 30 photographed sightings (7% of all sightings) are not of sufficient quality to be matched, but are thought to represent an additional five unique right whales.

Thus the total minimum count of right whales for the 1999 winter and spring surveillance program (as of 29 October, 1999) is 96 individuals identified in the Cape Cod Bay Critical Habitat area and adjacent waters between January and mid-May and five (5) individuals in the Great South Channel that were not seen in Cape Cod Bay in 1999.

Right whales were seen on the first aerial survey on 13 December 1998 (Figure 2) so it is not possible to establish the date of their entry into Cape Cod Bay. This pre-season flight, however, was

flown in response to unconfirmed reports of right whales in Cape Cod Bay from earlier in December. The last right whale was seen on 6 May (Figure 6) and this likely represents the end of the typical winter/spring residency period. The peak in sightings of right whales occurred between early March and mid April (Tables 2, 3 and 4, Appendix II). There were no sightings of mother calf pairs this year in Cape Cod Bay and adjacent waters. The count of mother calf pairs was very low in the southeast U.S. calving ground, only 3 pairs were seen between December, 1998 and March, 1999, plus one mother/calf pair (#2210) that was seen in the Great South Channel on 28 May by the NMFS research team. This was the third year (other years were 1995, 1998) since studies began in 1982 that no mother calf pairs have been sighted in Cape Cod Bay in the winter and spring.

Of the 86 right whales identified in Cape Cod Bay and matched to the catalogue, nine of those right whales had not previously been identified in the waters around Massachusetts prior to 1999 including: #s 1716, 1812, 1981, 2710, 2740, 2750 and three (3) new whales that do not have a catalogue number yet: 99-5, 99-42 and 99-183 (Appendix I). Two of these new whales, 99-42 and 99-183 have only been seen in Cape Cod Bay (Appendix I). There were nine first time residents of Cape Cod Bay identified in 1998 (1162, 1270, *1701*, *1968*, *2223*, 2240, *2271*, 2503, and *2705*), the five italicized whales were seen again in 1999 (Appendix I).

Three whales were documented outside of the Cape Cod Bay Critical Habitat Area. One right whale (#2304, a juvenile male) was seen in Cape Cod Bay but west of the western boundary on 1 May (Figure 6). The four previous sightings of this right whale in 1999 had all been in the Critical Habitat Area. There were three days on which the plane flew additional surveys to Wildcat Knoll and Stellwagen Basin following completion of the Cape Cod Bay tracklines. One whale was photographed in northern Stellwagen Basin (#1240, an adult female) that had not been seen in Cape Cod Bay (Figure 5). There were two surveys directed to the Great South Channel on the 11 and 12 of May. Five right whales were identified on 11 May, four of these had been seen earlier in Cape Cod Bay, and one (#1123, an adult female) had not. All of these whales have been seen in Cape Cod Bay in previous years (Appendix I).

There were aerial survey efforts undertaken in other known right whale habitat areas along the east coast in the winter and spring - in the southeast U.S. right whale calving ground (NEAq) and in the Great South Channel, Nantucket Sound (NMFS/NER), Platts Bank and Jeffereys Ledge (NMFS/NEFSC). Photo-analysis has been completed for the photographs submitted from the southeast U.S. sightings and five (5) of the 10 right whales seen in the southeast were also seen in during our flights. One whale (#2205) was a juvenile male, the other four were all females of known age who although adults have never been seen with a calf (#s 1703, age 12; 1711, age 12; 1909, age 10; 1911, age 10). All of these right whales have been seen in Cape Cod Bay in previous years.

Catalogue Number	southern sighting	northern sighting (days between sightings)
1703	07-Jan-99, GA	23-Mar-99, GSC (74 days)
1711	13-Jan-99, FL	14-Mar-99, CCB (59 days)
1909	07-Jan-99, GA	14-Mar-99, CCB (65 days)
1911	13-Jan-99, FL	16-Feb-99, CCB (33 days)
2215	31-Dec-98, FL	15-Feb-99, CCB (45 days)

Photographs from the other aerial survey efforts have not yet been fully analyzed thus it was not possible to document movements of right whales between Cape Cod Bay and nearby waters at this time, other than for the right whales that were seen in the Great South Channel from the DMF/CCS plane. The results of the two aerial surveys in the Great South Channel on 11 and 12 of May are mentioned above. There was a third flight of the Great South Channel in support of a disentanglement effort on 23 May, however this was 21 days after the last sighting of a right whale in Cape Cod Bay. Seven whales were seen of which six were photographed (#s 1123, 1133, 1152, 1306, and 1703), none of these whales had been seen in Cape Cod Bay in 1999, but they have in previous years. It is noteworthy, however, that one of these right whales #1133, an adult male, was next observed and photographed between 17 and 28 September 1999, in the Norwegian fiord Kvaenangen near Nordkapp (North Cape), Norway (69°57'N x 21°38'E), a distance of approximately 2400 nm from the Great South Channel.

Capture Rates and Residency

Of the 86 right whales identified in Cape Cod Bay and matched to an individual in the catalogue, 29 (34 %) were photographically captured on just one day (see below). The greatest number of days on which a single whale was captured was 16, # 1608, a 13 year old adult female, who has never been seen with a calf. Her sighting history spanned 108 days from 8 January to 25 April (Appendix II). This whale was seen on ten consecutive survey days, the most consecutive sightings of any whale this season. The second most frequently sighted whale was a new individual to the right whale catalogue, # 99-42, of unknown age and sex. This whale was seen 14 times over a 102 day span between 21 January and 1 May.

Days Photo'd	1	2	3	4	5	6	7	8	9	10	11	12	14	16
No. Photo'd (n = 86)	29	13	9	9	7	4	5	1	3	2	1	1	1	1

There were 57 right whales captured on more than one day (Appendix II). The number of days between first and last sighting was calculated for all right whales seen more than once. Three of these whales first seen on 13 December (#s 1507, 2406, and 99-5) had interruptions in their sighting records (101, 101 and 97 days respectively) and were not included in this analysis. The number of days between first and last sighting for 54 right whales ranged from 5-108 days, with the mean being 38.59 (S.E. = 26.57) days.

Demographics

Of the 86 right whales, there were slightly more males (37) than females (35) identified in Cape Cod Bay (14 of unknown sex, Table 4), but there was no significant difference from a one to one sex ratio ($P = 0.814$). When these data were compared with the sex of the catalogued right whales and the sex of right whales identified in this area in 1998, there was no significant difference in either case ($P = 0.225$, Hamilton *et al* 1998 and $P = 0.292$, Brown and Marx 1998 respectively). With respect to age, the sample was dominated by adults, with 64 % adults (n = 55), 27% juveniles (n = 23) and 9% of unknown age (n = 8). This age structure is not significantly different from that of the right whale catalogue ($P = 0.288$, Hamilton *et al* 1998) or from the age structure observed in Cape Cod Bay in 1998 ($P = 0.206$, Brown and Marx 1998).

Biopsy Samples

Biopsy samples were collected on four days in Cape Cod Bay in 1999. A total of ten samples were collected. Of note were samples from the three new whales to the catalogue (99-5, 99-42 and 99-183). A portion of the skin from these samples will be incorporated into ongoing genetics analyses. The remaining portion of the skin and blubber has been distributed to collaborators at three institutions, a description of how the samples from right whales will be incorporated in their research is included in Appendix IV.

Notification of Agencies

At the completion of each survey, the information on the number of right whales and their location that day was sent to the DMF office in Boston and the NMFS/SAS office in Woods Hole. A total of 40 faxes were sent to the DMF and copied to NMFS/SAS coordinator, one fax for each day in which Cape Cod Bay and adjacent waters were surveyed by either plane or vessel or both. In order to expedite the distribution of the information to the marine community, the number and location of right whales was relayed by cell phone at the completion of each aerial survey and at noon and at the completion of each vessel survey. The NMFS/SAS distributed faxes to the marine community after the noon report and again after the last report of the day. The faxes were sent following the completion of mapping the data (using the Andren LoranGPS software program), either later the same day or early the next morning. On days when both the vessel and plane surveyed, sightings were combined into one fax. Daily sightings of right whales were incorporated, as available, from other researchers operating in Cape Cod Bay and adjacent waters including: Dr. M. Moore (WHOI, M/V *Hannah T*) and David Wiley (International Wildlife Coalition, F/V *Wavelength*). The information contained in the fax included the location of each right whale sighting, the number of right whales per sighting and a chart showing the location of the sightings (Appendix III).

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Sighting Distances

The perpendicular distance from the aircraft at which right whales were sighted was determined by recording the exact position on the trackline when whales were initially sighted and then recording the exact position as the first pass was made directly over the animals. The number of sightings within each distance in $1/10^{th}$ nm intervals are shown in Figure 12. A total of 151 sightings were used in this analysis (secondary sightings that were made after the plane had already broken track were not included). Sighting distances ranged from the trackline to 2.7 nm away. The average sighting distance was 0.67 nm. Seventy-seven percent of the sightings were made with in one nm of the trackline and thirteen percent were made between one and one and a half nm.

Other sightings

There were at least six species of cetaceans, one species of pinniped and one species of shark sighted while performing these surveys (Tables 2 and 3, Figures 8 and 9). Fin whales, *Balaenoptera physalus*, were the most numerous other large whale encountered and white-sided dolphins, *Lagenoryhnchus acutus*, the most numerous dolphin. Sightings of all marine mammals and sharks were entered into the database after each survey.

This database also contains coded entries for vessel traffic observed in the area. Commercial and military vessel traffic were charted (Figure 10) to show their distribution relative to right whale sightings and the critical habitat area. These data are corrected for their position from the trackline.

Human Impacts

Entanglement Reports

In 1999, between 1 January and mid-May, there were three reports of entangled right whales, one was an observed temporary entanglement, one was a false report and the third was an unconfirmed report from an unknown location. The following section describes the reports and the actions taken. A detailed report of the event on 26 January is attached in Appendix V.

Report 1: 26 January 1999

The memorandum filed regarding this report is attached in Appendix V. In summary, the DMF/CCS aircraft was flying a regular surveillance flight when at 12:29, while they were circling to photograph right whales, saw one right whale that appeared from the air to be trailing about 100 m of line with an orange poly ball attached (Figure 1 in Appendix V). The observers could not see the gear directly attached to the whale because of the turbidity in the area. During further observation, the researchers noticed that the distance was increasing between the poly buoy and the whale. The conclusion of the researchers was that when they left the whale it was not entangled in any gear relating to this event. Photographs were obtained of the individual and it was later identified at right whale #1716, an adult male. This same whale was seen again the next day on 27 January and there was no evidence of an entanglement. The gear described, a single line and orange poly buoy, is not the type of gear that is permitted to be used in the Cape Cod Bay Critical Habitat Area or in Massachusetts waters so this gear must have come from outside of Cape Cod Bay.

Report 2: 26 January 1999

The U.S. Coast Guard was contacted regarding the above event and they went out in Coast Guard vessel 41491 to investigate (Appendix V). They encountered a right whale which they believed was entangled and obtained video footage of the whale. This footage was viewed three days later by the DMF/CCS right whale research team and the right whale was identified as # 1019, an adult male who has extensive scarring on its left flank from a previous collision with a ship and scarring on the flukes from a previous entanglement (Figure 2 in Appendix V). This whale was not entangled on 26 January 1999 when seen by the U.S. Coast Guard from vessel 41491. This event does underscore the importance of documentation of right whales for individual identification when they are encountered. If the Coast Guard had not obtained the footage, then we would have been under the mistaken impression that there was an entangled right whale in Cape Cod Bay.

Report 3: 25 April 1999

The US Coast Guard in Boston relayed a report of an entangled right whale observed by a private pilot. The whale was described as having silver net attached with line trailing and buoys, it was "twisting and turning and acting funny". Since the pilot did not have a GPS navigation system on board his aircraft, the position was determined by RADAR tower, Cape Approach. The R/V *Shearwater* departed research station to search for the animal at the position given by Cape Approach. The position was later determined to be incorrect. No entangled whales were seen in Cape Cod Bay during the remaining vessel day and four aerial surveys. The status of this whale is unknown, the species was never confirmed because there was no documentation. There is no net gear fished in the Cape Cod Bay Critical Habitat Area from 1 January to 15 May and in addition there was a Federal closure to gill nets from the shore on the west to east of Stellwagen Bank and from 42°00N x 42°30N latitude from February through April, 1999.

There were no whales photographed that showed any evidence of an entanglement in fishing gear in 1999. There is very little fixed gear in the critical habitat in Cape Cod Bay until gear restrictions are lifted on 15 May. There is, however, a rapid resumption of the fixed gear fishery in all of Cape Cod Bay immediately following the 16 May opening.

There were reports of two entangled right whales in the Great South Channel in the spring of 1999. Both of these whales, #s 1158 and 2710, were seen regularly in Cape Cod Bay during the winter and spring free of gear (Appendix II). Right whale # 1158, last seen in Cape Cod Bay on 1 April 1999, was seen entangled on 19 April 1999 in the Great South Channel by the S/V *Song of the Whale*, a sailing vessel operated by the International Fund for Animal Welfare (IFAW, Yarmouthport, MA). This whale was disentangled in September in the Bay of Fundy. Right whale # 2710, last seen in Cape Cod Bay on 25 April 1999 free of gear was seen in the Bay of Fundy on 21 July with line through the mouth, over the head and trailing behind. This was also disentangled in September in the Bay of Fundy.

Collisions with ships

On 20 April 1999, DMF/CCS right whale researchers were conducting a routine aerial survey of Cape Cod Bay. At 10: 45 a large black object was observed floating about 1.3 nm north of trackline 10 at latitude 41°53'N. The plane broke track and circled over the object. At 10:46 the floating object was determined to be the carcass of a North Atlantic right whale at position 41° 54.3N x 070° 09.7W. The aerial observers called in to CCS to report the carcass. The aircraft stayed on station and obtained both photographs and video footage of the animal. The plane circled for about 80 minutes and maintained a holding pattern over the whale until a vessel arrived. The observers reported there was no evidence of any fishing gear on the whale, nor any obvious marks on the visible surface of the animal floating left side up. The right whale was identified as # 1014, an adult female who had given birth at least six calves. The carcass was recovered and towed to shore by the R/V *Shearwater*. A full necropsy was conducted over the next three days. The findings of the necropsy revealed that this right whale suffered a blunt trauma which resulted in a fracture of the right mandible (jaw bone). The blunt trauma was likely caused by a ship strike. The histology indicated that the strike occurred 7-10 days prior to her death (Knowlton 1999). This whale had been seen on eight separate occasions between 17 January and 15 April (Appendix II), this last sighting occurred from the R/V *Shearwater* only five days before she was found dead and likely after she sustained the blunt trauma. Her second to last sighting occurred on 6 April in the south central portion of Cape Cod Bay. It is not known where this whale was located when she sustained her fatal injuries.

Discussion

Right whales spending the winter and spring in the Cape Cod Bay Critical Habitat Area have been the subject of an intensive research program in 1998 and 1999. Although there has been research efforts on right whales in this area since 1984, the last two years were more intensive in terms of the length of the research season (January to mid-May), the numbers of hours spent surveying in airplanes and vessels documenting right whales and the amount of data collected on individual animals. In 1999, a total of 96 right whales were identified of which 86 have been matched to an individual in the right whale catalogue. When the identification data from 1998 and 1999 were combined, a total of 122 different right whales have been documented in Cape Cod Bay in just the last two years (Appendix II), which represents 42% of the catalogued population. Although right whales

have been seen in Cape Cod Bay every month of the year, it was previously thought that this area was of prime importance between February and April (Schevill *et al.* 1986, Winn *et al.* 1986, Hamilton and Mayo 1990, Payne *et al.* 1990, Brown 1994). The data collected over the last two years clearly establish Cape Cod Bay as a primary winter and spring feeding area for right whales. This area is of prime importance to right whales from December through early May.

The subset of 86 individuals recorded in 1999 was used to examine the demographic profile of the winter and spring residents (Table 4). There were slightly more males seen than females, but the ratio was not significantly different from the catalogued population. More adults (64%) were seen than juveniles (27%) , but the percentages closely reflects that of the catalogued population which, uncharacteristically for a baleen whale, contains more adults than juveniles (Hamilton *et al.* 1998). The demographic profile of right whales using the Cape Cod Bay habitat area had previously been described as one dominated by females and the regular seasonal presence of mother calf pairs in the late spring (Brown 1994, Winn *et al.* 1986). There were no mother calf pairs seen in Cape Cod Bay in 1999, only the third such year (the other being 1995 and 1998) since 1982. In 1999, as in 1998, both the sex ratio and age structure of the winter and spring residents mirrored the demographics of the catalogued population suggesting that all segments of the population are now using the region and that earlier demographic profiles may have been biased by a shorter field season (usually February through April). A week by week demographic analysis is planned to investigate if there are seasonal patterns of habitat use by different segments of the population.

Right whales were in residence in Cape Cod Bay for at least 141 days, 33 days longer than documented in 1998. This is due, in part, to the first whales being seen on a pre-season flight on 13 December 1998 (reports of right whales were received at CCS in early December) and on every flight through 2 May 1999. Although the aerial survey effort continued in good conditions through 15 May, no more right whales were seen in Cape Cod Bay. The mean minimum residency time (number of days between first and last sighting) was 38.6 days, about five days longer than that recorded for 1998 (33.9 days) and almost three times the means of 11.8 days recorded for all right whales sighted between 1978 and 1986 (Hamilton and Mayo 1990), likely a result of increased effort in the last two years. The value of this expanded survey effort is underscored by the low number of whales that were only seen on one occasion in the last two years. In 1999, 34% of the whales were seen on only one occasion, similar that recorded for 1998 (31%), whereas in 1997, over half (57%) of the whales were only seen once (Hamilton *et al.* 1998). This suggests that some whales may be moving through the area more quickly at different times during the season and thus less likely to be recorded on more than one survey, and that some animals with short residency times could be missed. The data, however, will need to be corrected for effort in order to properly assess residency patterns in the area within a season.

The longest time to elapse between the first and last sighting of an animal was 108 days, but this individual was only seen on 16 days during that period when there were 27 survey days. This raises a number of questions about residency, was the whale in the Bay for the entire period, but not recorded in our surveys, or did it exit and reenter the Bay a number of times. Of the five whales seen on the first flight in December, three were recorded in Cape Cod Bay later in the season, but about 100 days after their initial sighting. This long gap between sightings and other gaps in sighting records within a season of two to three to four weeks in duration, despite the thorough survey coverage of the Bay, suggests there may be substantial movement in and out of Cape Cod Bay during a season. It is not known where right whales travel to when they depart the Bay in the winter months. The only other known winter

habitat area is the southeast US calving ground and we have yet to document a right whale in Cape Cod Bay prior to it being seen in the southeast US, although several have been recorded in Cape Cod Bay about a month after being sighted on the calving ground.

Our knowledge of medium-scale movements (medium-scale is defined as movements within an habitat area) both within Cape Cod Bay and within the larger area broadly defined as adjacent waters, is quite poor and confounds our ability to understand how individual right whales use this area during their stay. It is important to understand the nature of right whale movements in the area to assess if there are some individuals or certain times during the season when animals are at increased risk from entanglement or ship collision from travels outside of the critical habitat area. The lack of knowledge about medium scale movements of right whales within Cape Cod Bay and in and out of the Bay to nearby areas was highlighted in 1999 by the death of right whale # 1014, nicknamed Staccato, who was found floating dead on 20 April. This whale was seen in Cape Cod Bay on nine different survey days during the 89 day span between her first and last sighting (Appendix II). This whale was determined by necropsy to have died from blunt trauma, likely the result of a ship collision, but we have no information on whether that collision took place while # 1014 was within Cape Cod Bay Critical Habitat or if she was struck when outside the critical habitat and traveled back into the area when injured. The trauma was estimated to have taken place 7-10 days pre-mortem, and her last sighting in Cape Cod Bay was five days prior to the discovery of her carcass. She was likely already fatally injured at her last sighting alive, but there were no obvious signs of any injury.

The questions surrounding residency and medium-scale movements and can really only be addressed when whales are tagged with a radio-monitored transmitter (satellite-monitored transmitters are useful only on much larger scales) and literally followed around in a vessel for as long as the weather and tag attachment permits. In addition, subsequent sightings of the tagged animal(s) in Cape Cod Bay during regular aerial surveys also would give us some measure of the frequency of sighting whales that are known to be in the survey area. That would give us information on whether a whale like # 1608 that was seen on 10 consecutive surveys days over a 26 day period (Appendix II) actually remained in the Bay the entire time and what its movements were within the Bay.

In Cape Cod Bay, the area with the greatest potential overlap between vessels and right whales occurs at the eastern end of the Cape Cod Canal (Figures 2-10). Although right whales are usually found in the middle and eastern portions of the Bay, there are records of right whales west of the western boundary of the critical habitat area (Figure 6 and Brown and Marx, 1998). Operators of the canal receive regular reports on the distribution of right whales in Cape Cod Bay and adjacent waters from NMFS/SAS which they in turn relay to transiting ships. In 1999, the Army Corps of Engineers took fast action to minimize the risk of collision between vessels and right whales by closing the canal for about 45 minutes on 16 April because of the presence of two right whales in the mouth of the eastern entrance. The USCG assisted by placing one of their vessels next to the whales and stood by until the whales left the area. In the absence of a technical solution to the problem of vessel collisions with whales, the only available options are governmental regulation to minimize the probability of collisions and voluntary efforts by those who operate vessels. More research is needed on how right whales detect and respond to oncoming vessels.

The aircraft based surveillance and photo-identification efforts has proved to be a useful and effective survey platform in this habitat area. All but four (~5%) of the identified right whales were

seen from the airplane, the four additional identifications of right whales were from photographs taken opportunistically from the R/V *Shearwater* during habitat sampling cruises. Photographs collected from the research vessel were an important part of the photo-identification effort for: identifying animals not seen from the air; for getting good photographs of scars and lesions; assessing the health of whale; and to assist in the matching of animals photographed from the air but for which no previous aerial photographs exist. While more data on the identification of the whale and any associated scars or marks are collected from a vessel-based photograph (NEAq unpublished data), on several occasions whales were seen from the aircraft that were not visible to observers on a nearby boat because the whales were sub-surface feeding. Some of these whales were photographed from the airplane while their callosity pattern was submerged and the photographs were of sufficient quality to be matchable. This photographic technique, however, was not always successful, in some instances the whale was either too deep, the surface of the water was too rough or the water not clear enough to permit individual identification. Thus it is important to maintain the photographic effort from both vessel and aerial based platforms.

The data collected over the last two years has established Cape Cod Bay as an important right whale habitat area to a significant portion of the population. One of the more valuable products of this work is the increased awareness generated throughout the maritime community about the presence of right whales in these waters from December to May and the conservation efforts in Cape Cod Bay to foster their recovery.

Acknowledgments

We are most grateful to all of our dedicated colleagues who spent the winter and spring in planes and on boats in Cape Cod Bay to make this work possible. Aerial observers included Kevin Creighton (DMF), Juliette Finzi (CCS), Tim Frasier (CCS), Bob Hoffman (DMF), Rob Johnston (DMF), Jeremy King (DMF), Dan McKiernan (DMF) and Cathy Quinn (NEAq/CCS). Thank you to Philip Hamilton, Amy Knowlton and Cathy Quinn at New England Aquarium with for their invaluable contributions analyzing data and final matching of right whales to the catalogue. Special appreciation is extended to Chandler Lofland and John Ambroult who kept our plane flying smoothly all season, and to Ed Lyman who, in addition to his research and other duties, kept all the boats shipshape under winter conditions. We would also like to extend our thanks to Captain Russell Webster of the USCG for providing us with a pre- and post-flight call-in service to make sure we landed safely and on hard ground.

The oceanographic sampling and photo-identification efforts aboard R/V *Shearwater* were conducted by Dr. Stormy Mayo, Captain Ed Lyman and Juliette Finzi with the assistance of Captain John Baldwin, Joanne Jarzobski, Scott Landry, Margaret Murphy, Carol Pearl, Cathy Quinn, and Peter Borrelli. Additional biopsy darting and photo identification surveys on R/V *Gannet* were carried out with the help of Amy Knowlton. We would also like to thank Michael Moore for a day of biopsy darting and photo identification on the M/V *Hannah T.* Many thanks to Charlie Westcott and Lynn Hiller for keeping everything running smoothly on the administrative end of the project. Special thanks to Jennifer Beaudin Ring who work so diligently to prepare the figures for this report.

These vessel and aerial surveys were conducted under a Scientific Permit to Take Marine Mammals No. 1014, issued by the NMFS to Scott Kraus, NEAq until we obtained our own permit in March of 1999. For the remainder of the field season, surveys were conducted under a Scientific Permit to Take Marine Mammals No. 633-1483-01 issued by the NMFS to Dr. Charles Mayo. This permit is valid until 31 March 2004. A report of our research activities for 1999 will be submitted to NEAq. This work was supported primarily by a contract from the Massachusett Division of Marine Fisheries, the habitat portion of the program was supported by a grant to Dr. Mayo from the Massachusetts Environmental Trust.

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Table 1. Aerial Survey Tracklines in Cape Cod Bay: 1999.
(Tracklines end approx. 15 nm from land).

Trackline number	Latitude	Longitude West End	Longitude East End	Trackline length (nm)
1	42 06.5	70 38.0	70 10.0	21.0
2	42 05.0	70 37.0	70 14.0	17.3
3	42 03.5	70 38.0	70 15.0	17.3
4	42 02.0	70 36.0	70 07.7	21.2
5	42 00.5	70 34.3	70 06.9	20.6
6	41 59.0	70 35.2	70 06.6	21.5
7	41 57.5	70 34.4	70 06.6	20.9
8	41 56.0	70 31.6	70 06.3	19.0
9	41 54.5	70 30.8	70 03.1	20.8
10	41 53.0	70 30.0	70 03.1	20.2
11	41 51.5	70 30.0	70 02.1	20.9
12	41 50.0	70 30.0	70 02.1	20.9
13	41 48.5	70 30.0	70 02.2	20.9
14	41 47.0	70 29.0	70 04.1	19.4
15	41 45.5	70 26.0	70 11.0	11.3
Subtotal trackline miles in Cape Cod Bay, tracks 1-15				293.2
16*	41 45.5		69 53.0	25.0
Total trackline miles, tracks 1-16				318.2

*Trackline 16 starts at this point and runs northeast, paralleling the coast, ~3 miles offshore until the eastern end of trackline 1.

Table 2. Numbers of marine mammals seen including right whales, and hours, and trackline miles surveyed during aerial surveillance of Cape Cod Bay, 1999.

Date 1999	# Egs Sighted	# Egs Photo'd	Bp	Mn	Ba	UNBA	UNLW	La	Pp	Pv	UNDO	Cm	Gm	Hours Surveyed	Trackline Miles	Tracks Completed
13-Dec '98	5	5	2	0	0	0	0	2	0	0	5 - 10	0	0	3.8	293.2	1-15
6-Jan	6	5	0	0	0	0	0	18	0	0	6	0	92	3.5	272.3	1 - 6, 8 - 15
8-Jan	8	6	1	0	0	1	0	85	0	0	0	0	6	4.1	306.9	1 - 14, 16
21-Jan	7	5	0	0	0	0	0	10	0	9	0	0	219	4.5	318.2	1-16
22-Jan	3	3	0	0	0	0	0	0	0	0	0	0	8	3.2	306.9	1-14, 16
26-Jan	10	10	0	0	0	0	0	0	0	0	0	0	0	4.1	318.2	1-16
27-Jan	12	12	0	0	0	0	0	0	0	2	0	0	0	5.4	318.2	1-16
1-Feb	15	12	0	0	0	0	0	0	0	0	0	0	0	4.9	318.2	1 - 16
2-Feb	10	7	0	0	0	0	0	0	0	0	0	0	0	2.7	153.4	8 - 15
15-Feb	4	4	1	0	0	0	0	0	0	0	0	0	0	3.3	297.2	2 - 16
16-Feb	16	15	0	0	0	0	0	0	0	0	0	0	0	4.8	318.2	1 - 16
17-Feb	6	5	0	0	0	0	0	0	0	0	0	0	0	3.5	318.2	1 - 16
24-Feb	9	6	0	0	0	0	0	0	0	0	0	0	0	4.4	318.2	1 - 16
28-Feb	6	4	0	0	0	0	0	0	0	0	0	0	0	3.5	262.6	4 - 16
3-Mar	21	18	0	0	0	0	0	0	0	2	0	0	0	5.4	318.2	1 - 16
6-Mar	6	1	0	0	0	0	0	0	0	0	0	0	0	1.1	82.1	11-14
10-Mar	5	4	0	0	0	0	0	0	0	0	0	0	0	3.4	318.2	1-16
14-Mar	16	14	0	0	0	0	0	0	0	0	0	0	0	4.2	300.9	1, 2, 4-16
21-Mar	14	7	0	0	0	1	0	0	0	0	0	0	0	4.3	318.2	1-16
25-Mar	11	8	2	0	0	0	0	0	2	1	0	0	0	2.8	226.3	4-14
26-Mar	12	10	0	0	0	1	0	0	0	0	0	0	0	4.4	318.2	1-16
31-Mar	29	10	1	0	0	0	0	0	0	4	0	0	0	2.9	234.8	4-14*, 16
1-Apr	19	16	1	0	0	0	0	180	20	1	0	0	0	5.5	318.2	1-16
6-Apr	25	24	5	5	2	0	0	25	0	1	0	0	0	5.4	405.4	1-16, plus Stellwagen Basin
9-Apr	17	16	6	0	1	0	1	20	0	1	0	0	0	3.9	306.9	1-14, 16
11-Apr	17	15	13	0	2	0	0	15	0	0	0	0	0	4.9	306.9	1-14, 16
15-Apr	20	19	14	6	1	0	1	20	1	2	0	0	0	5.2	318.2	1-16
20-Apr	15	15	18	3	3	0	0	1	0	1	0	0	0	5.2	279.9	3-16
21-Apr	11	11	12	1	3	0	0	50	0	0	0	0	0	4.6	318.2	1-16
25-Apr	15	15	13	0	0	1	1	20	1	0	0	0	0	4.4	318.2	1-16
28-Apr	2	2	47	15	6	1	0	550	0	0	0	0	0	5.1	443.8	1-15, 14 (x2), plus Stellwagen Basin
1-May	3	3	18	5	5	0	0	7	0	0	0	0	0	4.1	318.2	1-16
2-May	1	1	9	2	1	0	1	90	0	0	0	0	0	4.1	318.2	1-16
10-May	0	0	3	1	0	0	0	135	0	0	4	0	0	6.5	469.0	1-16, plus Wildcat Knoll
11-May**	7	7	12	29	3	3	0	340	0	1	0	3	0	4.4	430.0	Great South Channel
12-May**	0	0	9	1	17	0	0	29	6	0	0	2	0	4.2	430.0	Great South Channel
13-May	0	0	0	0	1	0	0	0	0	0	0	0	0	2.4	216.4	5-15
15-May	0	0	2	17	2	0	0	0	1	0	30	0	0	3.4	318.2	1-16
Totals	383	315	189	85	47	8	4	1597	31	25	45-50	5	325	157.5	11752.5	

Eg (right whale), Bp (finback), Mn (humpback), Ba (minke), UNBA (unidentified balaenopterid), UNLW (unidentified large whale), La (white-sided dolphin), Pp (harbor porpoise), Pv (harbor seal), UNDO (unidentified dolphin), Cm (basking shark), and Gm (pilot whale).

*Turned 3 miles from shore on western side because of high winds, 1.5 miles subtracted from tracklines 4-14.
**Survey in the Great South Channel.

Table 3. Numbers of marine mammals seen including right whales, and hours and miles surveyed during vessel surveillance of Cape Cod Bay, 1999.
Abbreviations for marine mammals are in Table 2, UNSE (unidentified seal).

Date	Vessel	#Egs sighted	# Egs photo'd	Bp	Mn	Ba	UNLW	La	Pp	Pv	UNSE	UNDO	GM	Hours Surveyed
19-Dec '98	SW097	2	0	0	0	0	0	7-14	0	0	0	0	0	2.5
6-Jan	SW098	0	0	0	0	0	1	24-37	0	0	0	0	0	5.0
17-Jan	SW099	14	4	0	0	0	0	0	0	0	0	0	0	3.5
21-Jan	SW100	11	8	1	0	0	0	215	0	8	0	0	150	8.0
22-Jan	SW101	4	2	0	0	0	1	20 - 30	0	0	0	0	0	3.4
26-Jan	SW102	3	0	0	0	0	0	0	0	0	0	0	0	5.0
27-Jan	SW103	11	5	0	0	0	0	37	0	0	0	0	0	8.3
2-Feb	SW104	14	2	0	0	0	0	0	0	0	0	0	0	3.7
9-Feb	SW105	3	1	0	0	0	0	0	0	0	0	0	0	6.5
11-Feb	SW106	0	0	0	0	0	0	0	0	0	0	0	0	1.7
16-Feb	SW107	7	4	0	0	0	0	10-20	0	1	0	0	0	7.2
24-Feb	SW108	10	2	0	0	0	0	0	0	1	0	0	0	9.0
3-Mar	SW109	19	10	0	0	0	0	0	0	0	0	1	0	9.0
10-Mar	SW110	10	5	0	0	0	0	0	0	1	0	0	0	10.8
21-Mar	SW111	16	11	0	0	0	0	0	0	4	0	0	0	9.9
26-Mar	SW112	13	3	0	0	0	0	0	0	0	0	0	0	7.9
1-Apr	SW113	14	1	0	0	0	0	0	4	4	0	5	0	9.5
1-Apr	GT001	8	6	0	0	0	0	0	0	0	0	0	0	5.5
3-Apr	SW114	16	7	0	0	0	0	0	0	0	0	0	0	6.5
6-Apr	HT001	36	22	0	0	1	0	0	0	0	0	0	0	8.1
9-Apr	SW116	8	7	0	0	0	0	0	0	1	0	0	0	7.1
14-Apr	GT002	1	0	0	0	1	0	0	0	0	0	0	0	2.3
15-Apr	SW117	5	5	2	0	2	1	0	2	3	1	0	0	11.3
19-Apr	GT003	18	17	8	0	0	0	0	2	0	0	0	0	7.9
19-Apr	SW118	8	7	2	0	0	1	0	0	0	0	0	0	9.3
20-Apr	GT004	1	1	0	0	0	0	0	0	0	0	0	0	5.0
25-Apr	SW120	7	5	10	1	1	0	150	0	1	0	0	0	11.5
1-May	SW121	0	0	2	0	0	0	0	0	0	0	0	0	11.5
Totals		259	135	25	1	5	4	426-466	8	24	1	6	150	196.9

Vessel abbreviations: SW = R/V Shearwater; GT = R/V Gannet; HT = M/V Hannah T.

Table 4. Number of surveys, demographic composition and number of right whales identified from both aerial and shipboard surveys two-week intervals during mid-December 1998, and from January and mid-May, 1999 in Cape Cod Bay.

Two week intervals	13-19 Dec* 1998	1-14 Jan 1999	15-28 Jan	29 Jan-11 Feb	12-25 Feb	26 Feb-11 Mar	12-15 Mar	26 Mar-8 Apr	9-22 Apr	23 Apr-6 May	7-15 May**	Total
a) Surveys												
Aerial	1	2	4	2	4	4	3	4	5	4	5	38
Shearwater	1	1	5***	3	2	2	1	3	3	2		23
Gannett								1	3****			4
Hannah T								1				1
b) Demographics												
Male	1	1	10	3	8	11	8	14	11	5	0	
Female	1	1	11	8	11	15	14	18	16	6	0	
Unknown sex	3	3	2	2	3	3	5	6	6	4	0	
Juvenile	1	3	5	0	8	9	7	10	9	6	0	
Adult	3	1	17	11	12	19	15	23	20	6	0	
Unknown age	1	1	1	2	2	1	5	5	4	3	0	
Total right whales id'd	5	5	23	13	22	29	27	38	33	15	0	
c) Resightings												
New Sightings	5	5	19	3	10	16	10	12	6	0	0	
Resightings	0	0	4	10	12	13	17	26	27	15	0	

* This interval represents one week.

** This interval represents 9 days.

*** One Vessel trip to investigate report on entangled whale.

****One vessel trip to locate and recover a dead right whale on April 20, 1999.

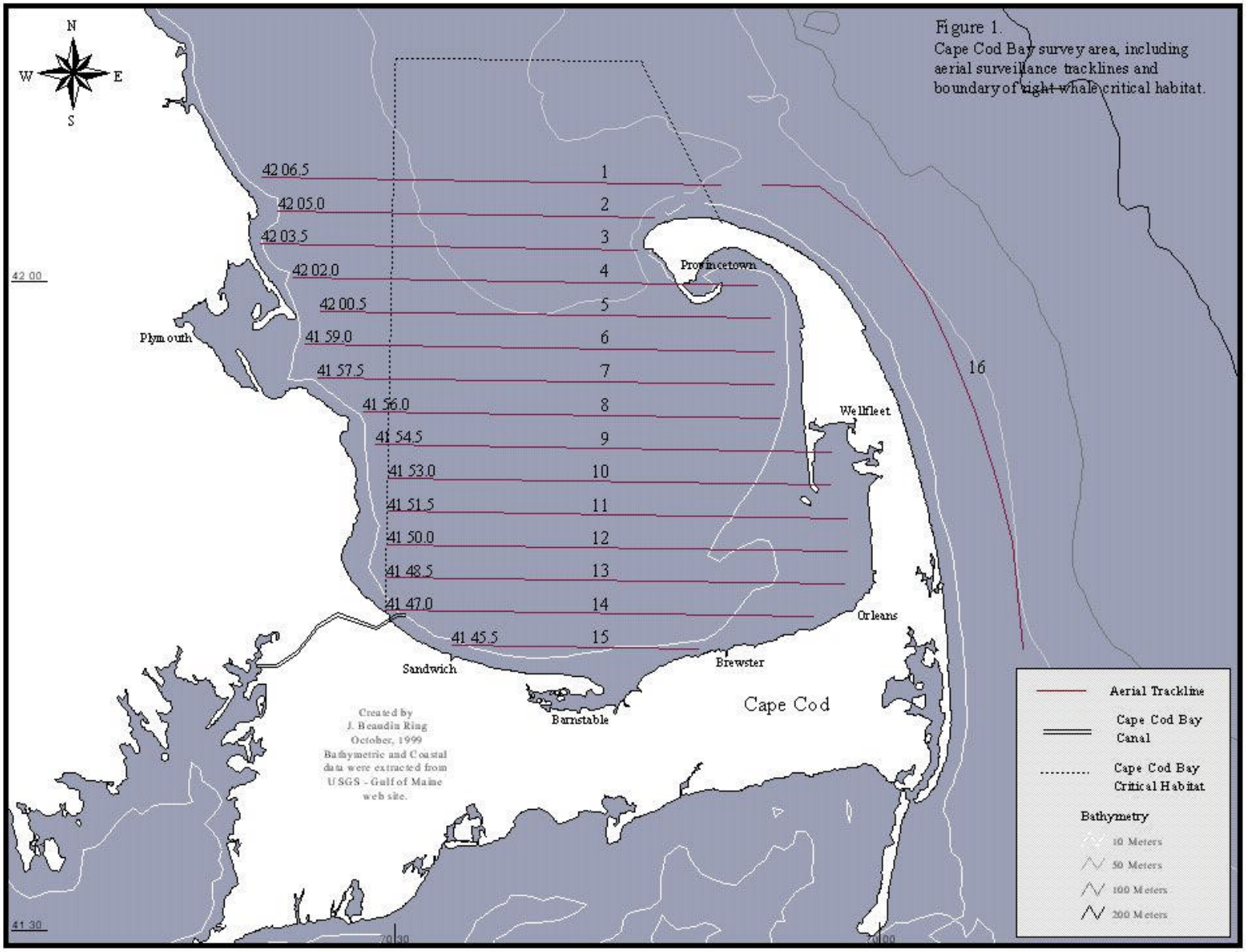
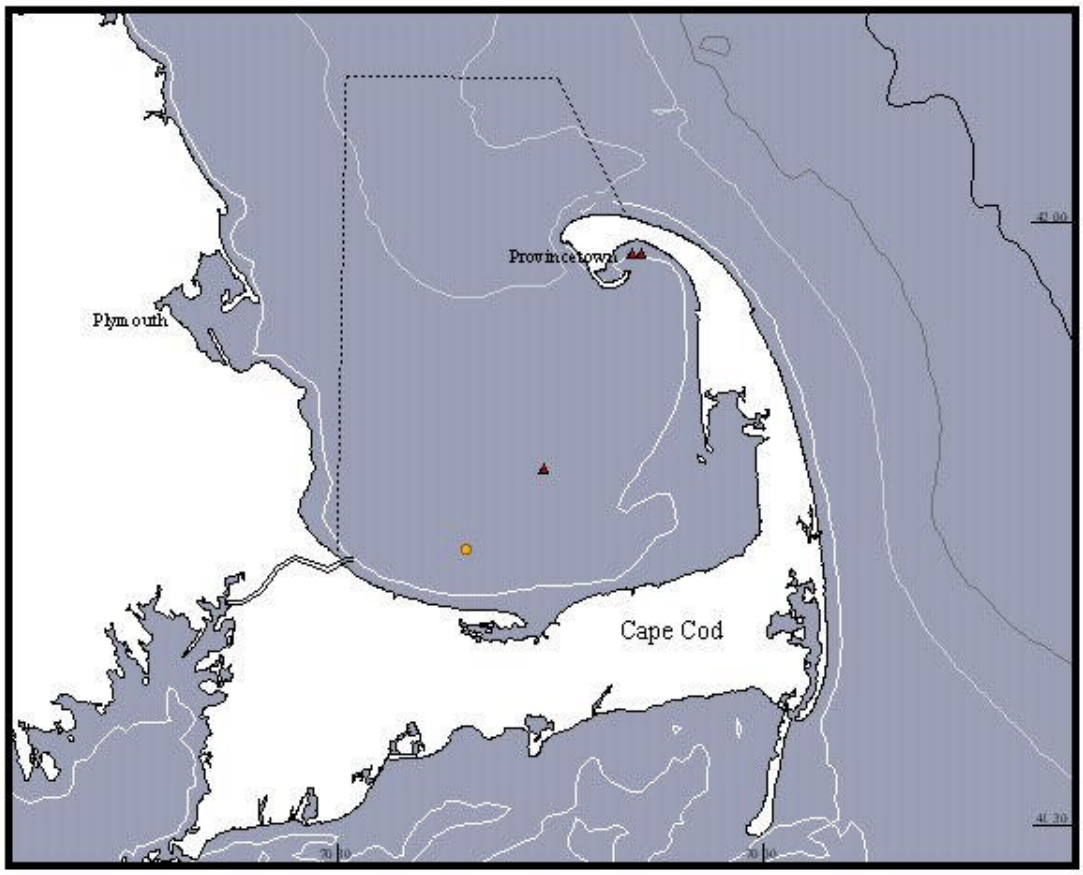
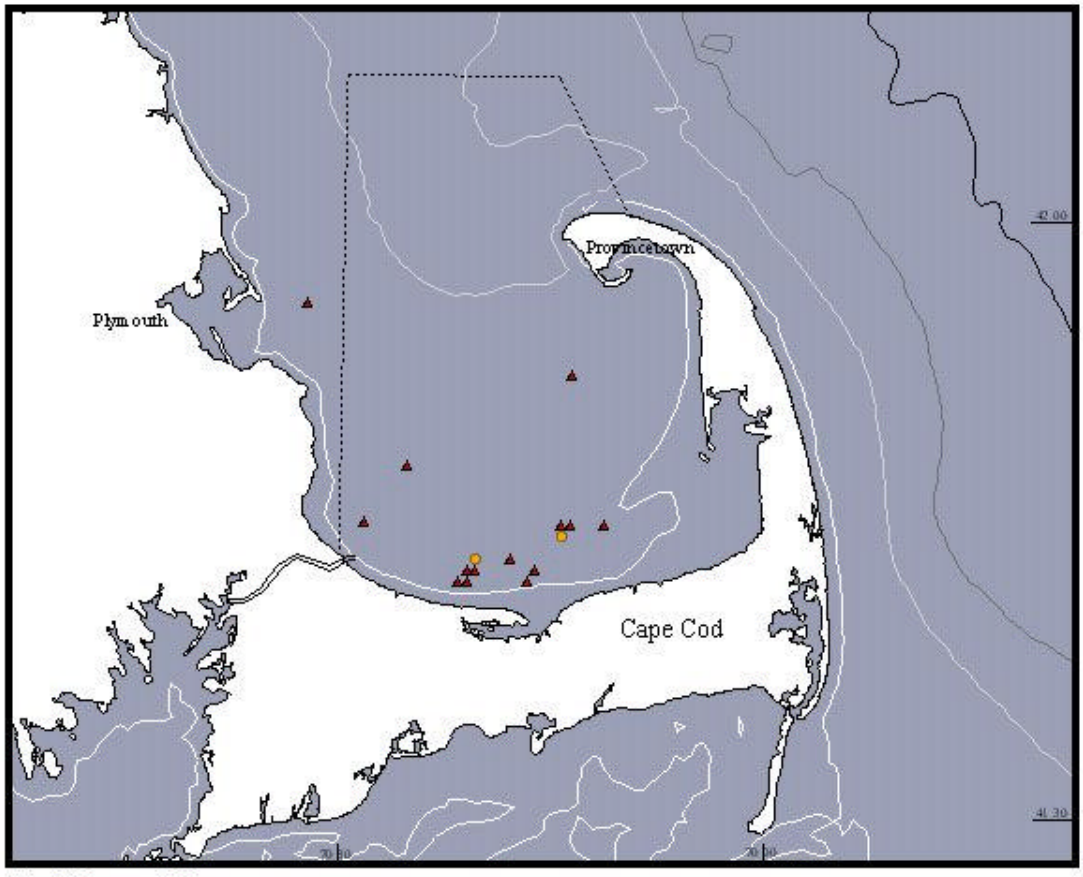


Figure 1.
Cape Cod Bay survey area, including aerial surveillance tracklines and boundary of right whale critical habitat.



a. 13 December, 1999.



b. 1 - 14 January, 1999.

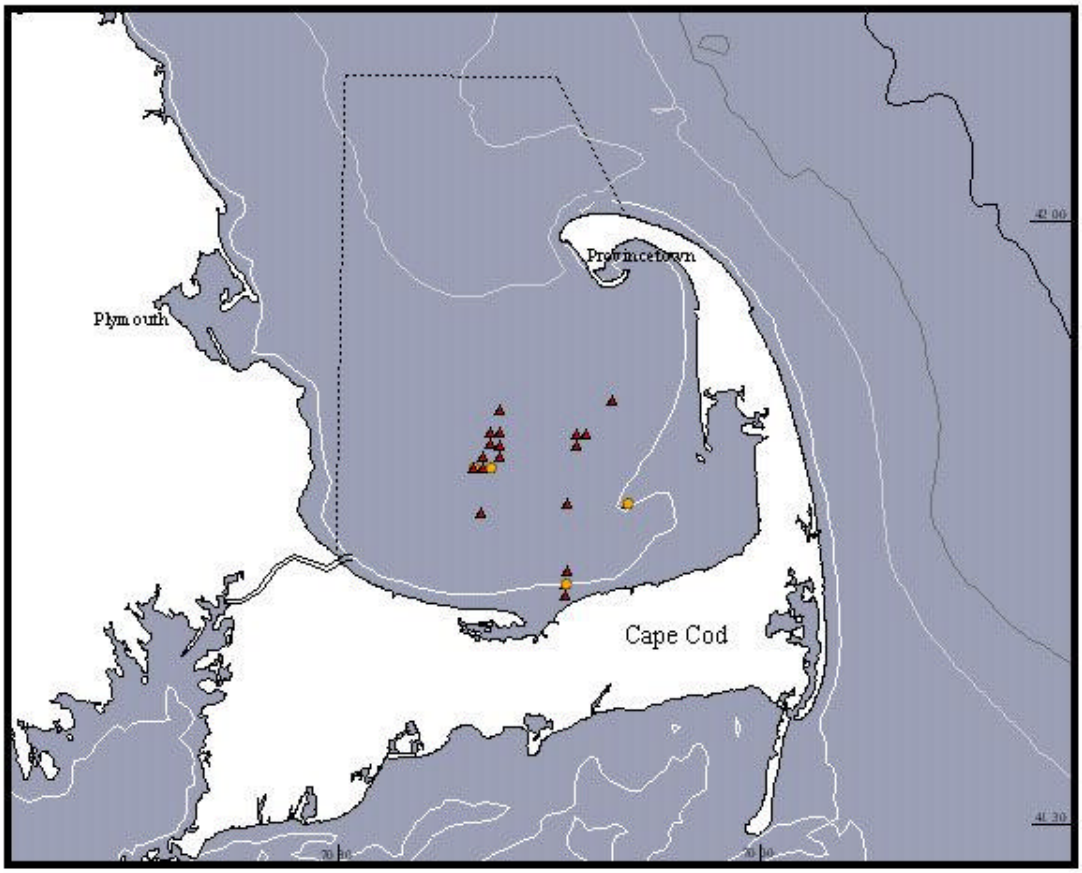
Figure 2.
Sightings of right whales from aerial surveys in Cape Cod Bay, 13 December - 14 January, 1999.

Numbers of Animals Sighted
1 animal
2 - 5 animals

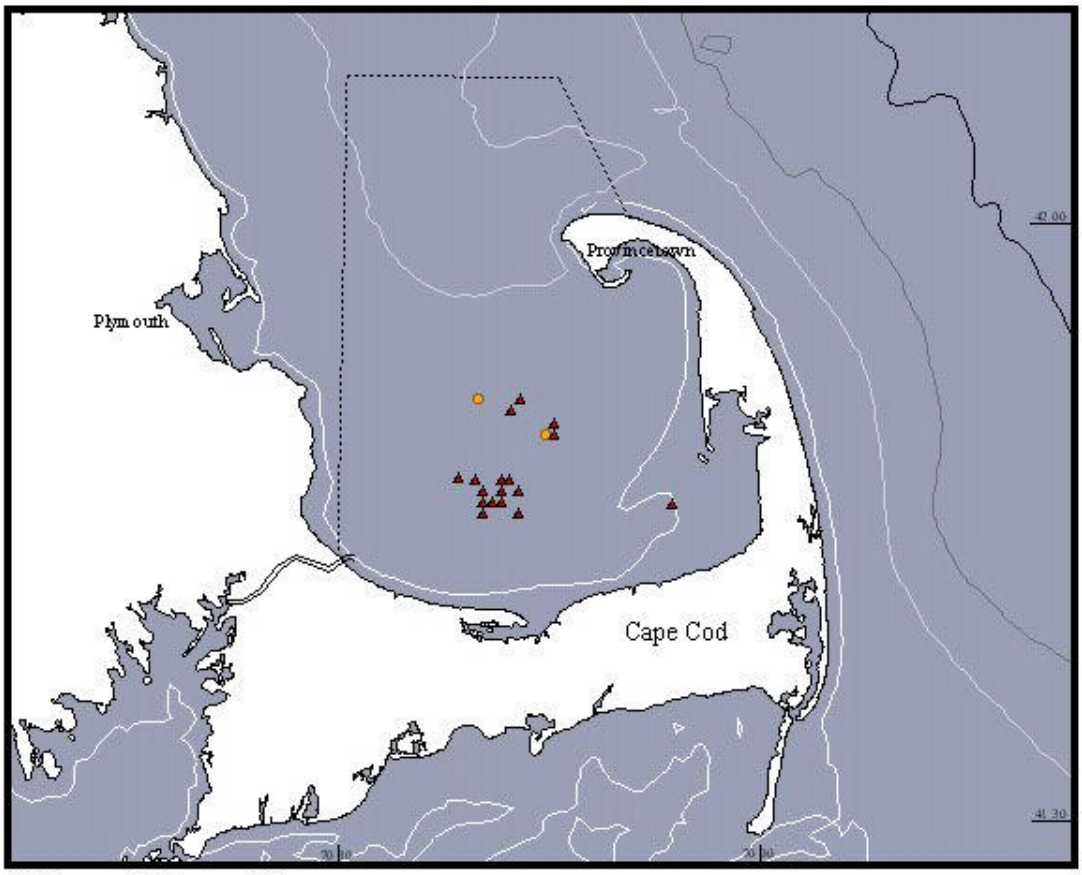
Bathymetry
10 Meters
50 Meters
100 Meters
200 Meters
Cape Cod Canal
Cape Cod Bay Critical Habitat

Created by
J. Beaudin Ring
October, 1999
Bathymetric and Coastal data were extracted from USGS - Gulf of Maine web site.

N
W
E
S



c. 15 - 28 January, 1999.



d. 29 January - 11 February, 1999.

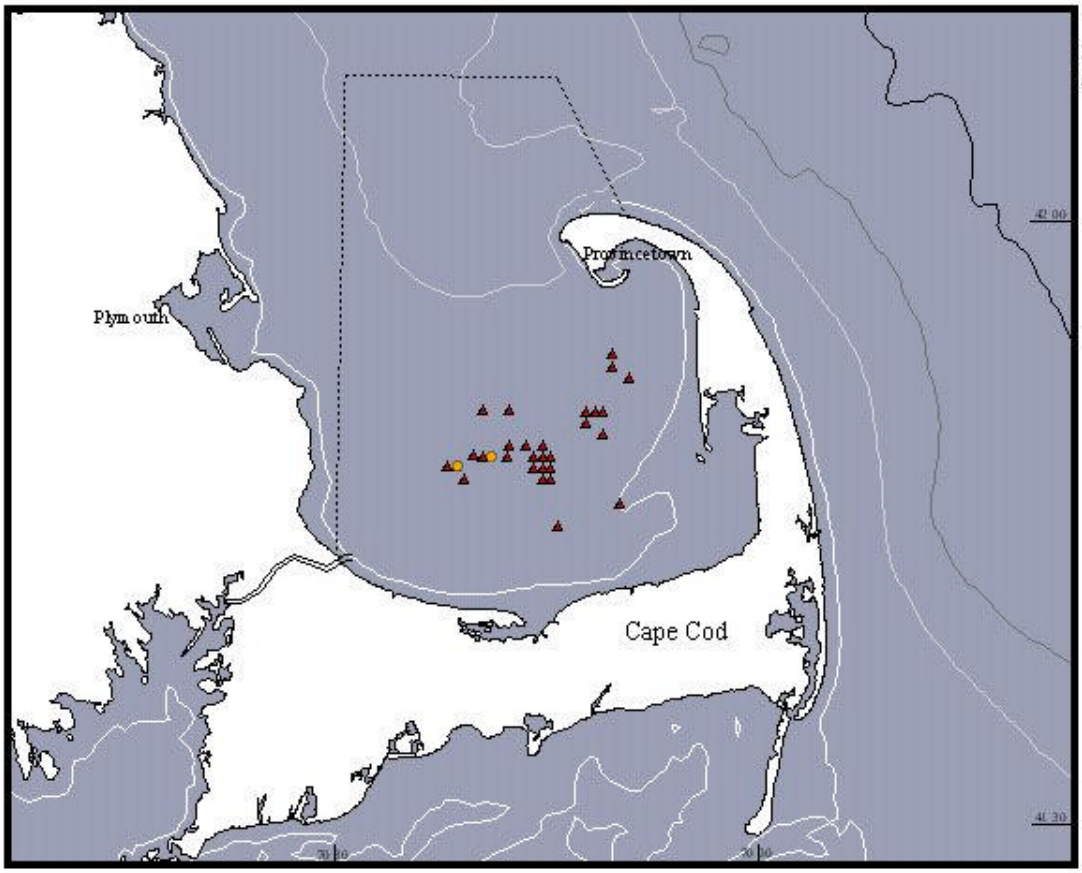
Figure 3.
Sightings of right whales from aerial surveys in Cape Cod Bay, 15 January - 11 February, 1999.

Numbers of Animals Sighted
1 animal
2 - 5 animals

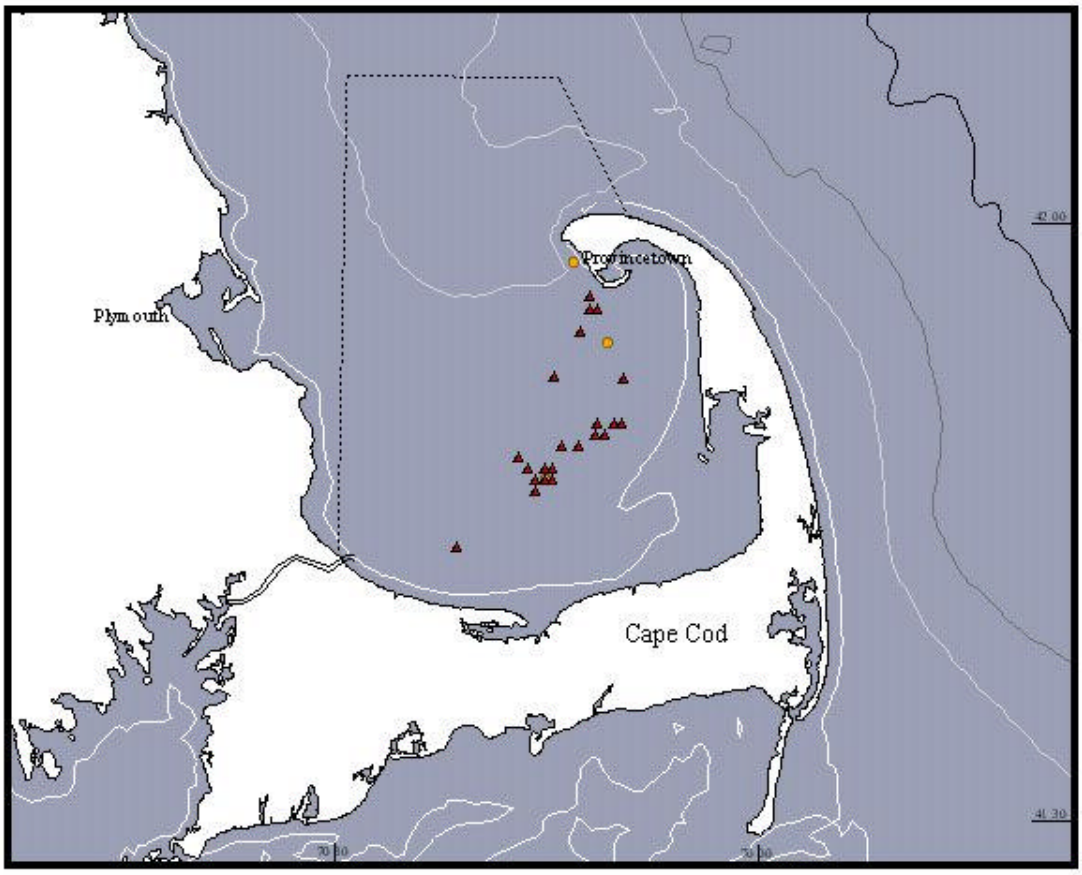
Bathymetry
10 Meters
50 Meters
100 Meters
200 Meters
Cape Cod Canal
Cape Cod Bay Critical Habitat

Created by
J. Beaudin Ring
October, 1999
Bathymetric and Coastal data were extracted from USGS - Gulf of Maine web site.

N
W E
S



e. 12 - 25 February, 1999.



f. 26 February - 11 March, 1999.

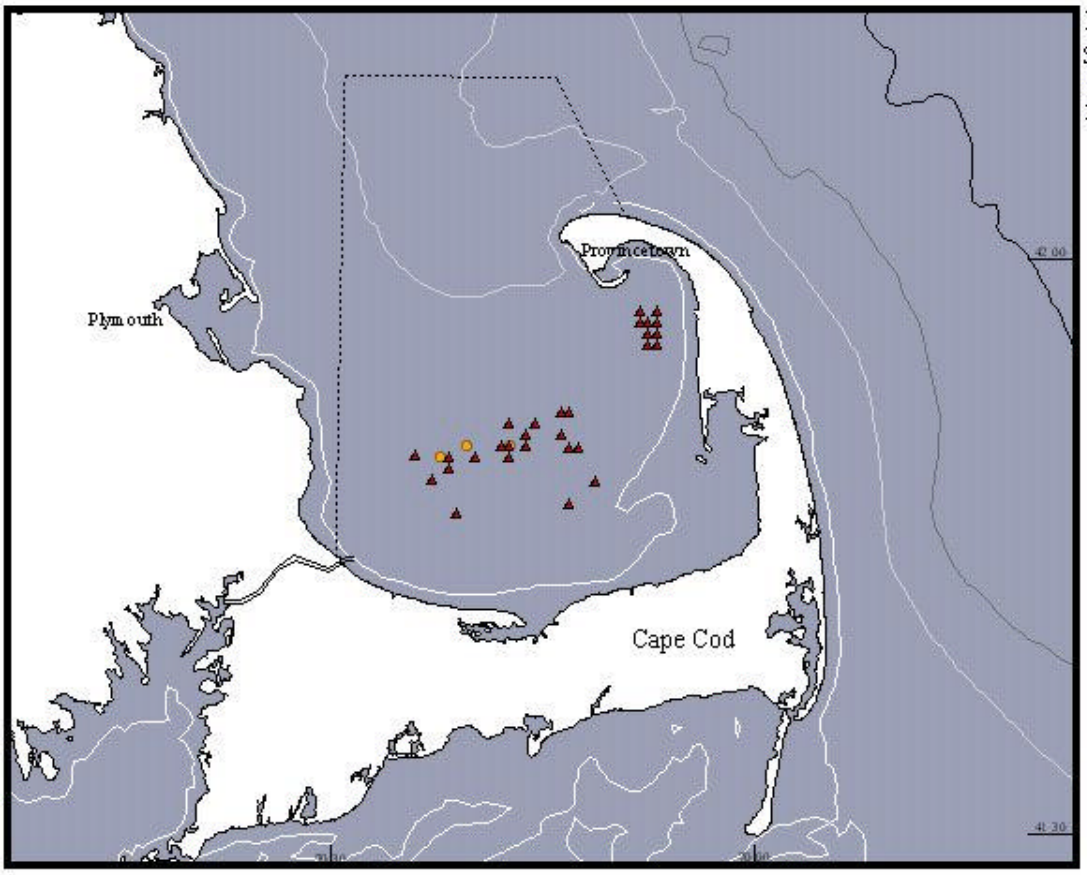
Figure 4.
Sightings of right whales from aerial surveys in Cape Cod Bay, 12 February - 11 March, 1999.

Numbers of Animals Sighted
1 animal
2 - 5 animals

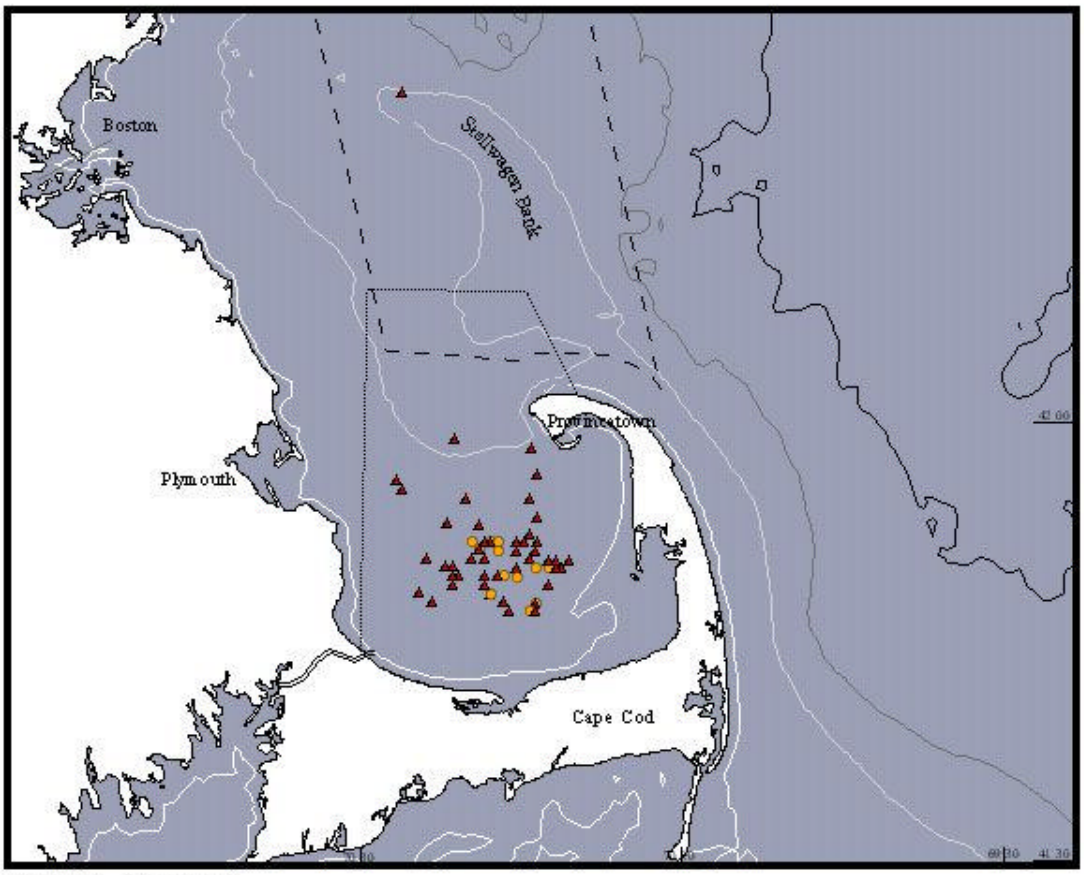
Bathymetry
10 Meters
50 Meters
100 Meters
200 Meters
Cape Cod Canal
Cape Cod Bay Critical Habitat

Created by
J. Beaudin Ring
October, 1999
Bathymetric and Coastal data were extracted from USGS - Gulf of Maine web site.

N
W
E
S

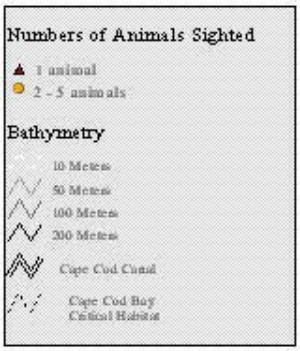


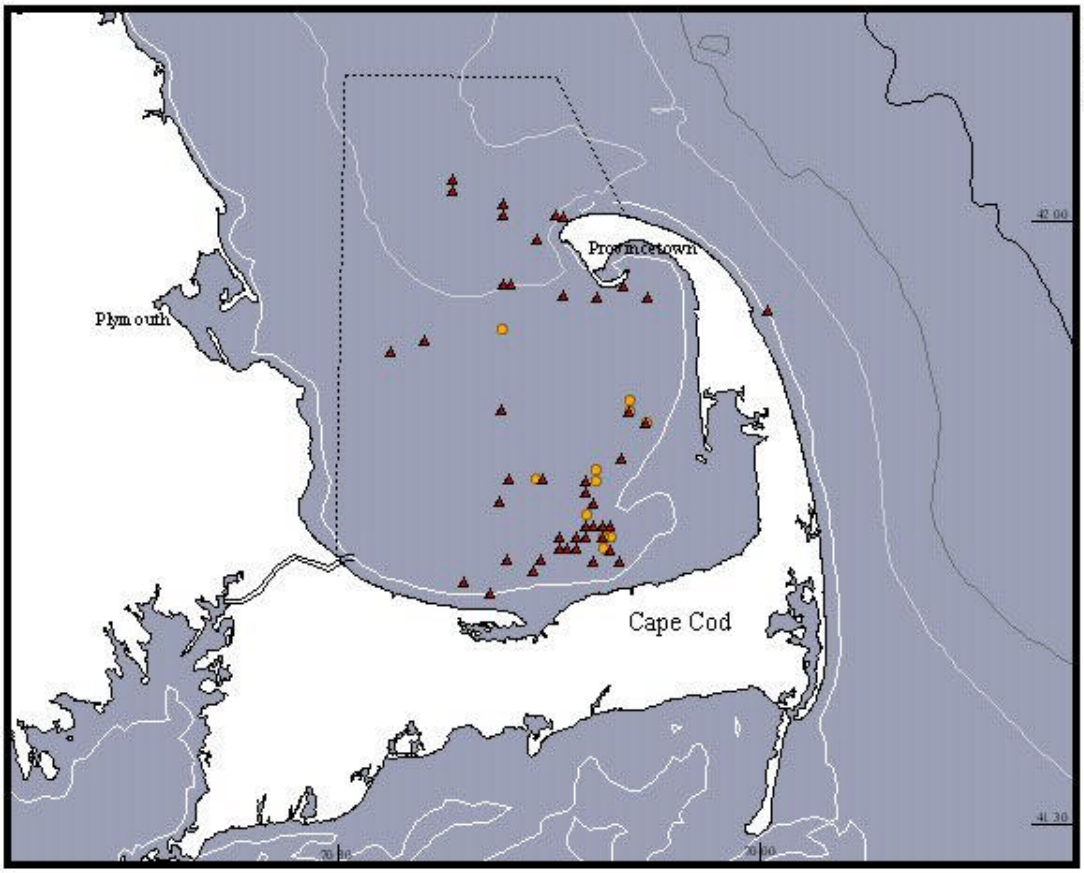
g. 12 - 25 March, 1999.



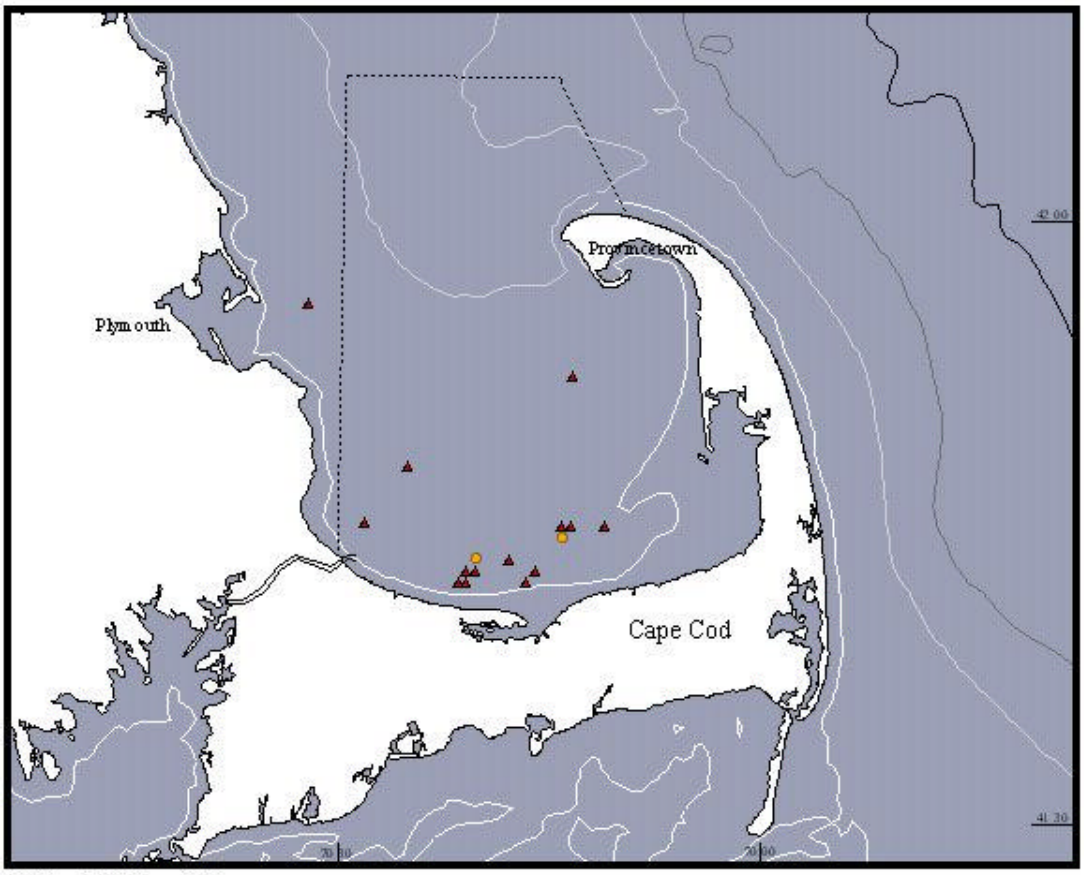
h. 26 March - 8 April, 1999.

Figure 5.
Sightings of right whales from aerial surveys in Cape Cod Bay, 12 March - 8 April, 1999.



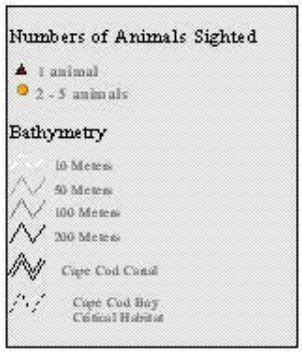


i. 9 - 22 April, 1999.



j. 23 April - 6 May, 1999.

Figure 6.
Sightings of right whales from aerial surveys in Cape Cod Bay, 9 April - 6 May, 1999.



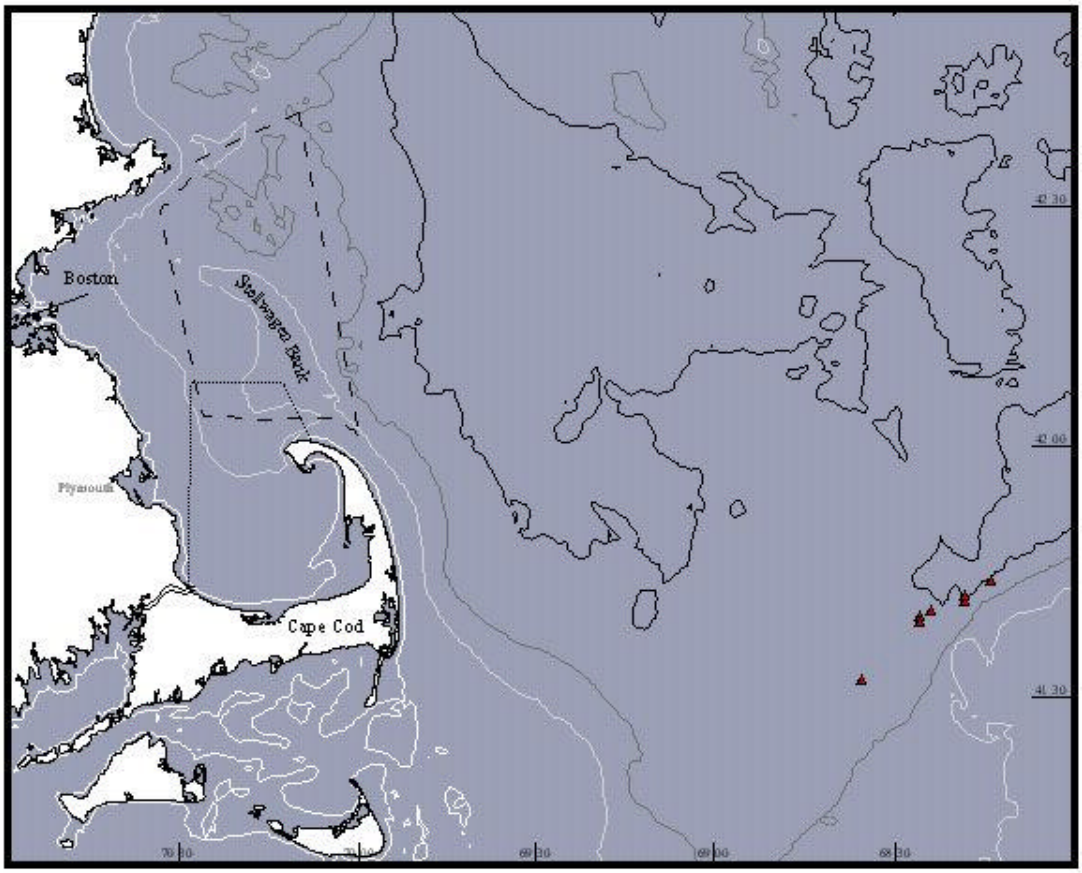


Figure 7.
Sightings of right whales from aerial surveys in Cape Cod Bay, 7 - 15 May, 1999.

k. 7 - 15 May, 1999.

Legend for Figures 8. and 9.
Large Whales and Dolphins

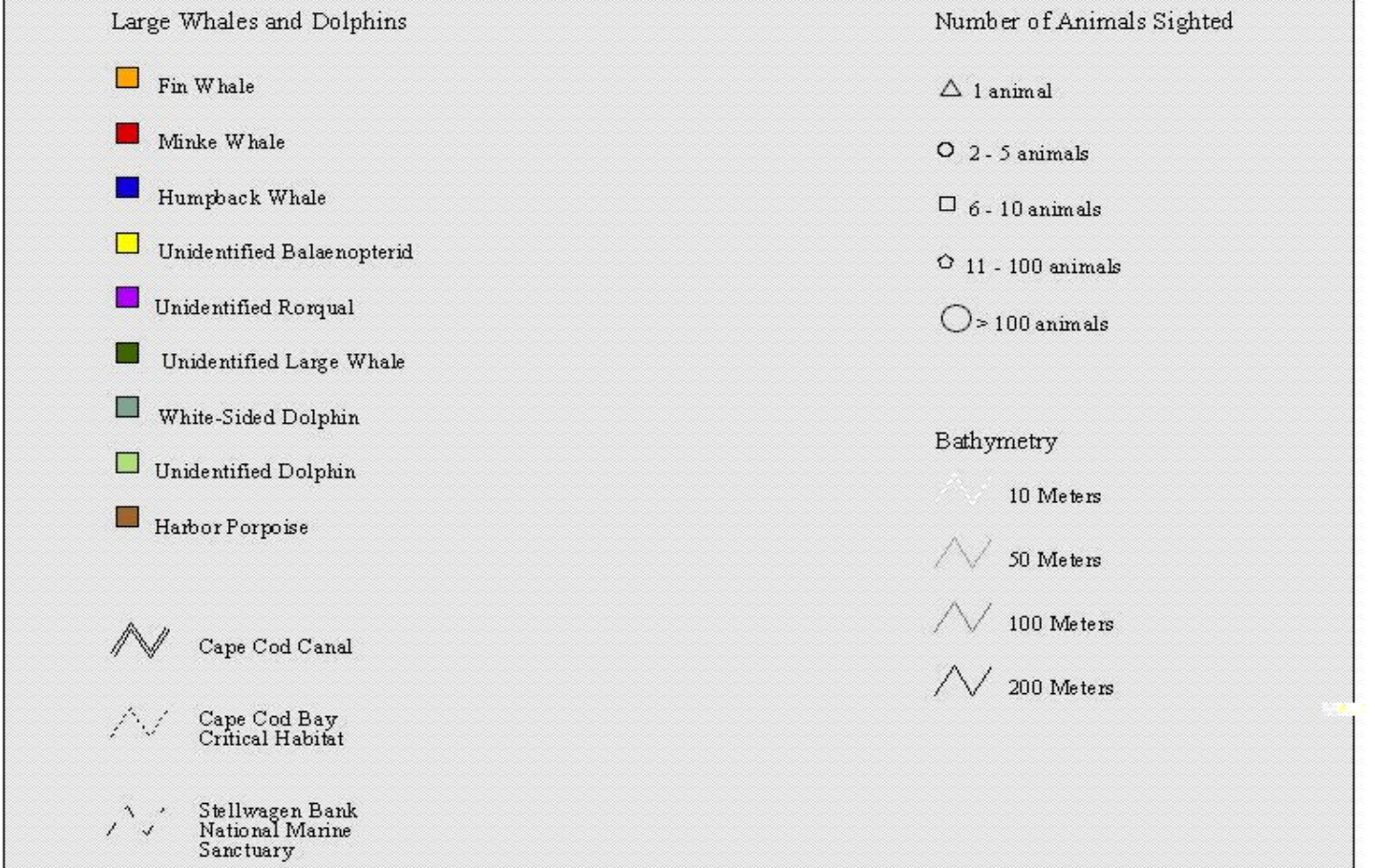
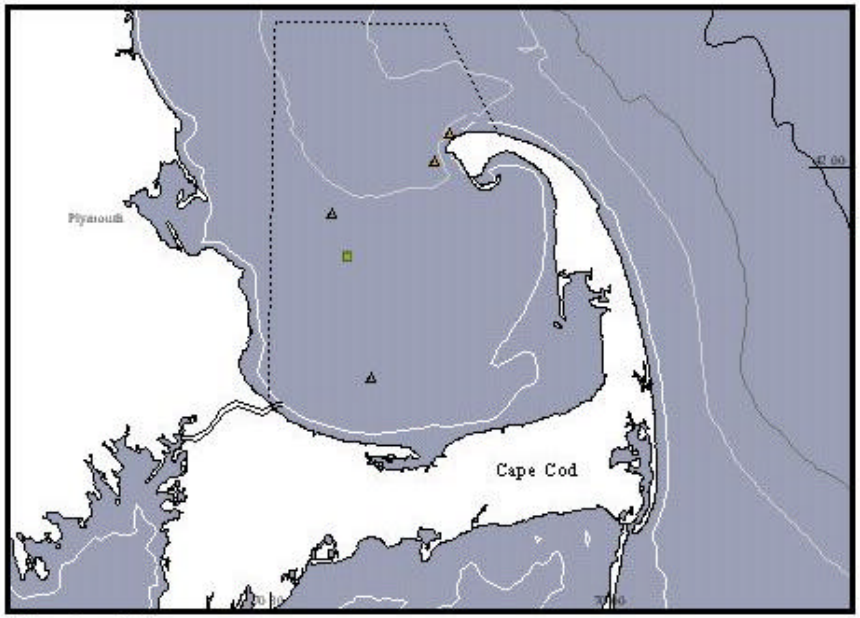
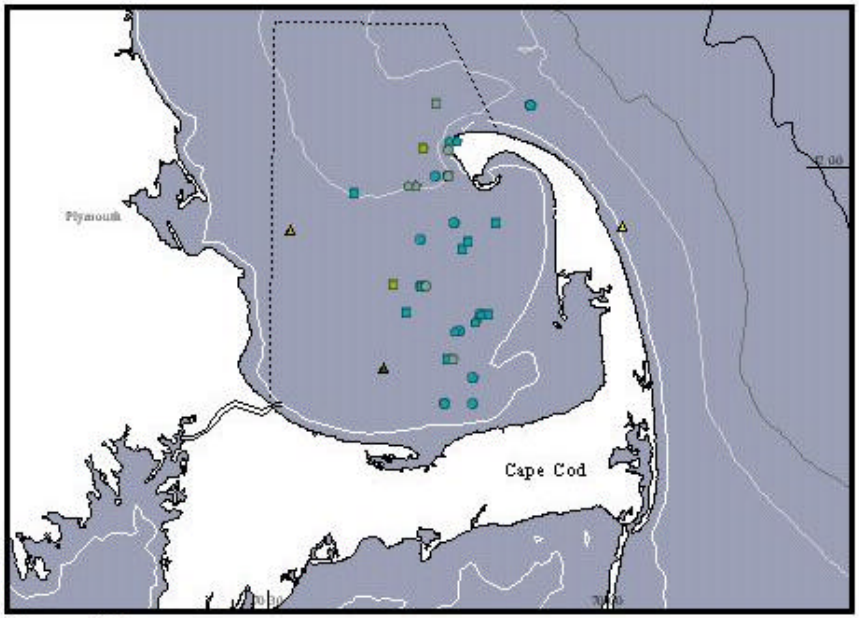


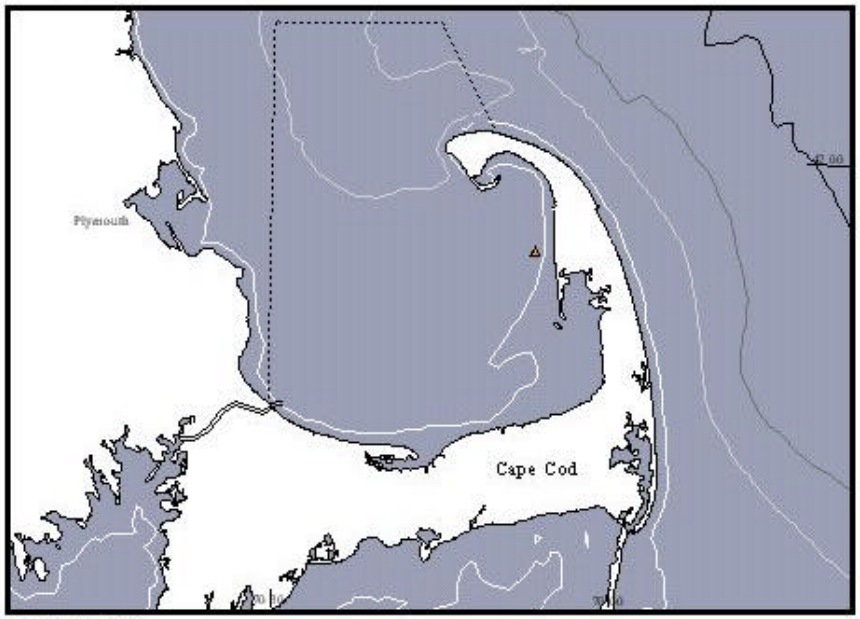
Figure 8.
Sightings of other large whales and dolphins
from aerial surveys in Cape Cod Bay,
December - March, 1999.



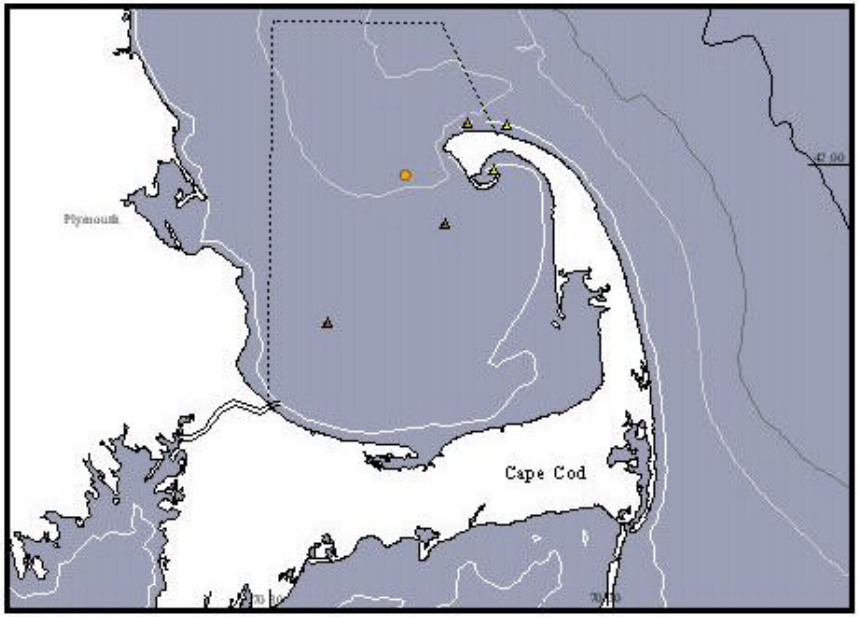
a. December, 1999.



b. January, 1999.

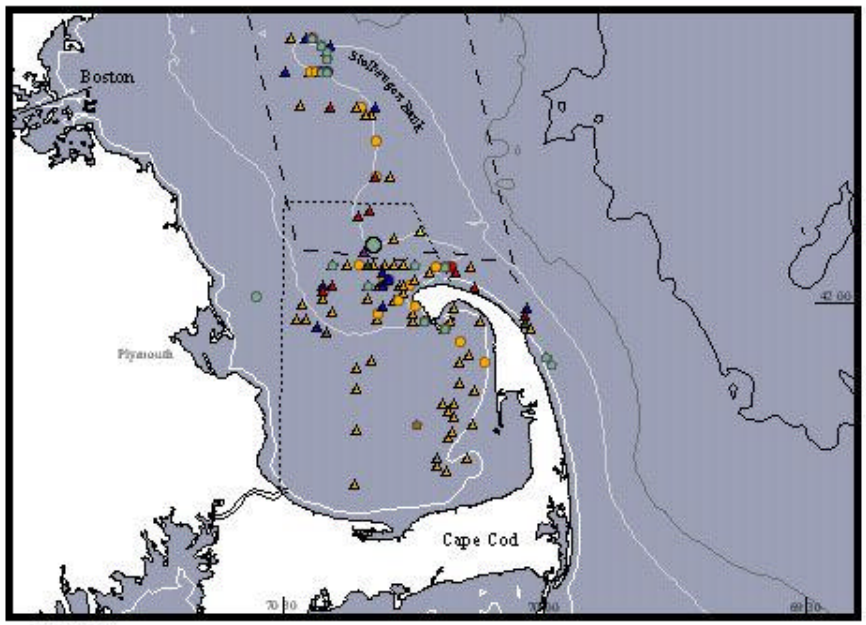


c. February, 1999.

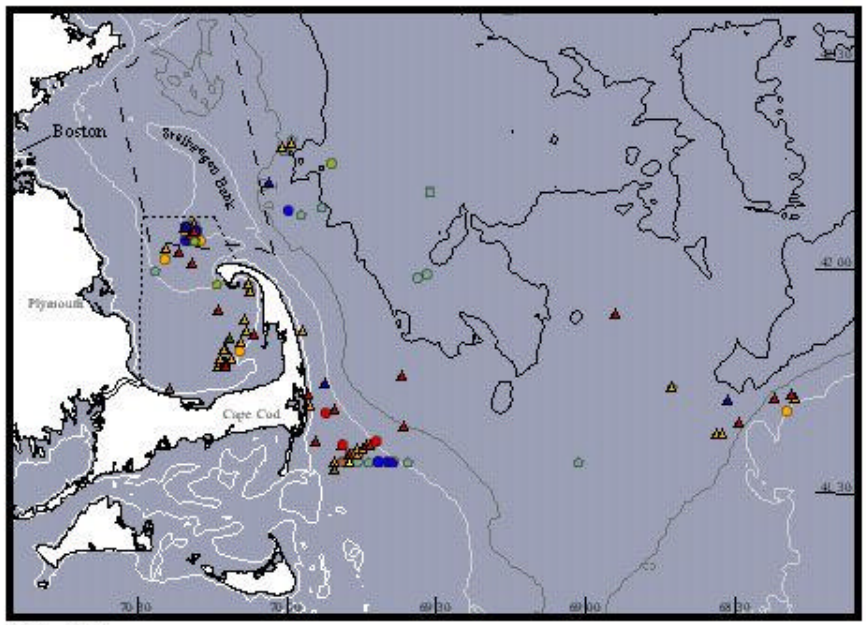


d. March, 1999.

Figure 9.
Sightings of other large whales and dolphins
from aerial surveys in Cape Cod Bay,
April - May, 1999.



e. April, 1999.



f. May, 1999.

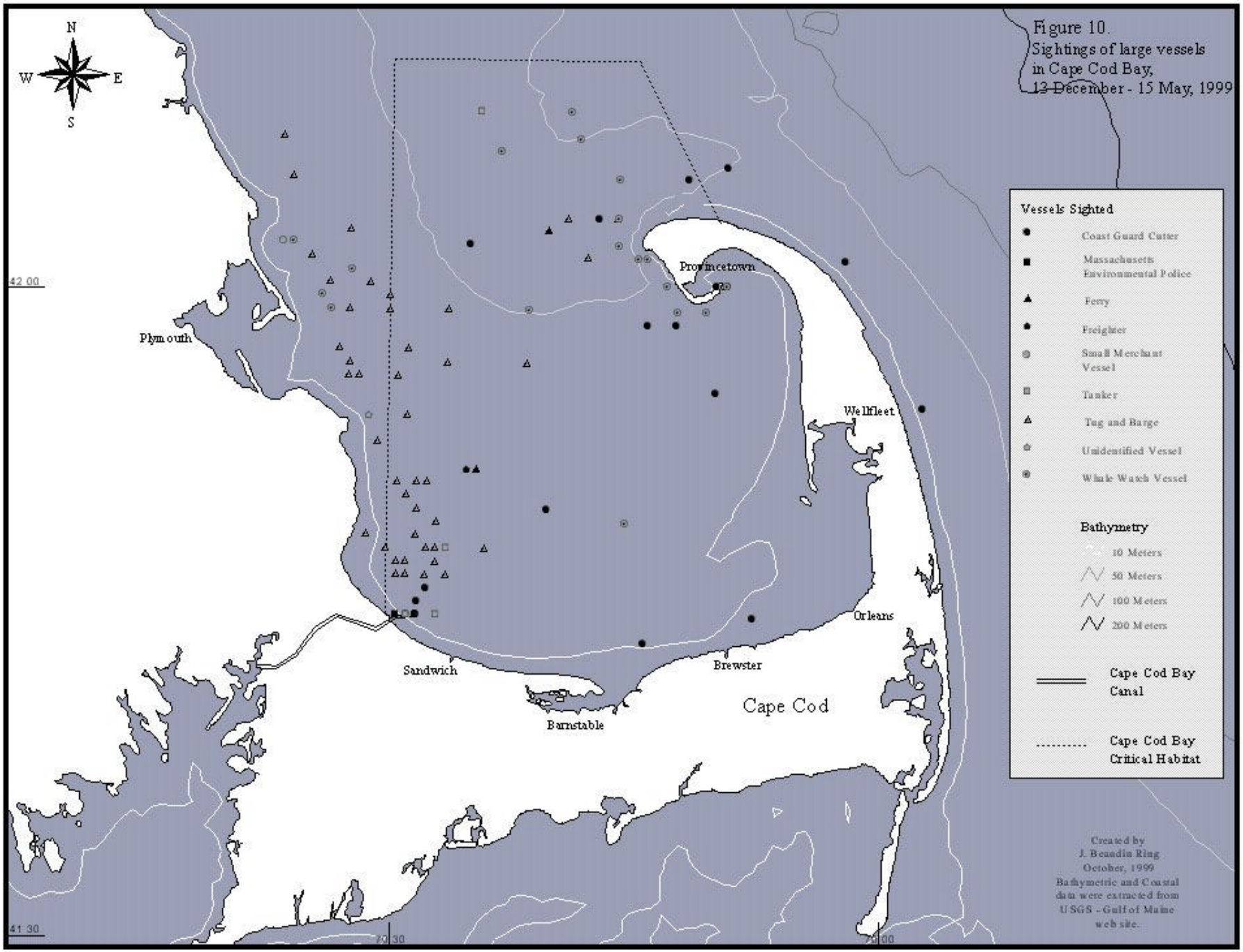
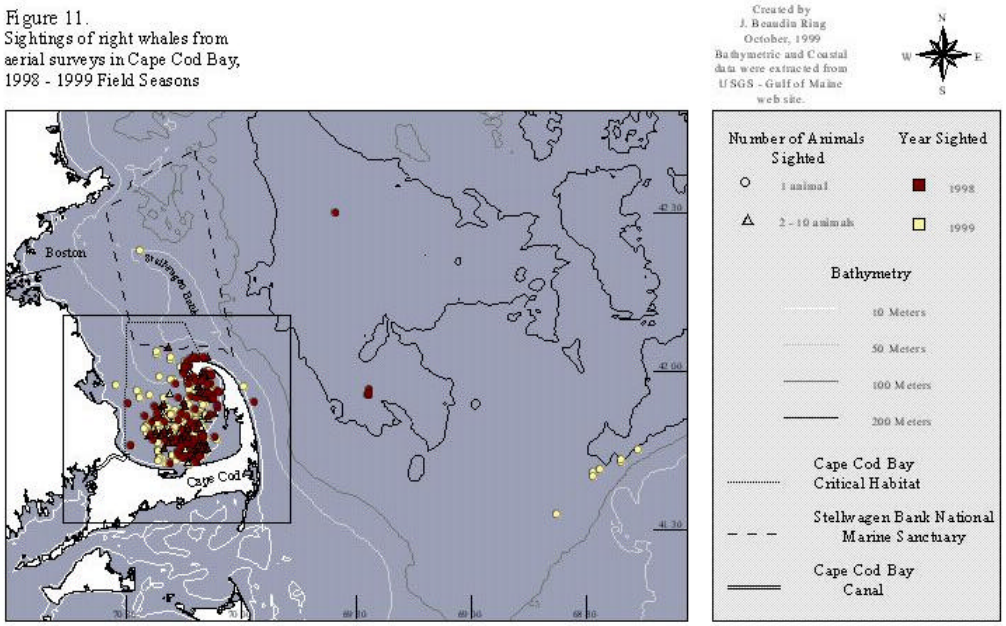
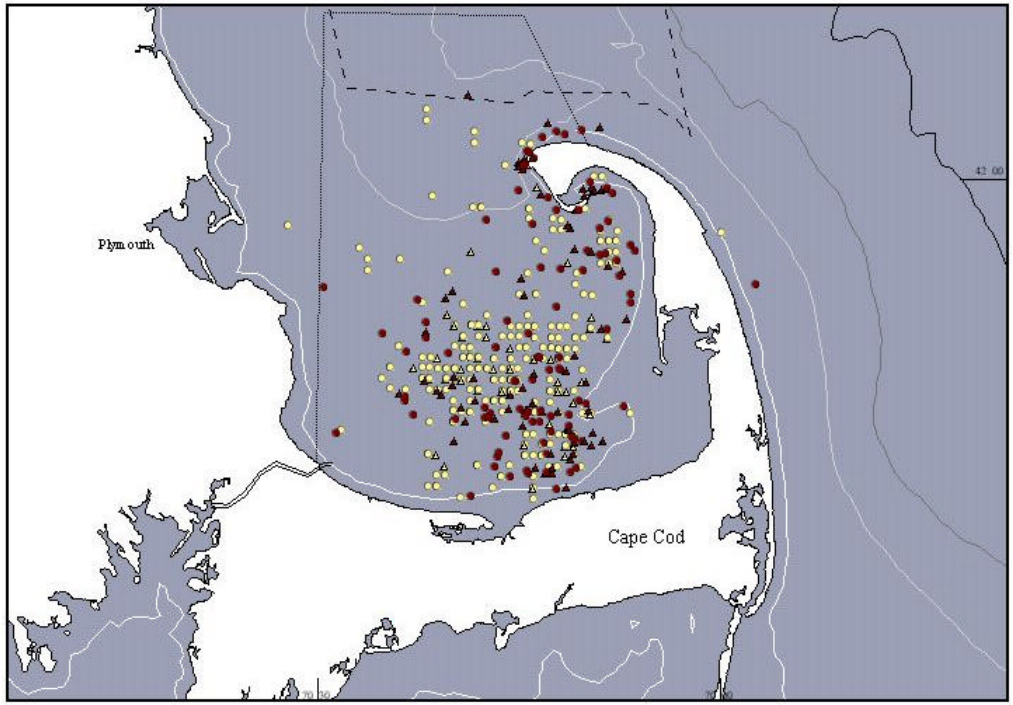


Figure 10.
Sightings of large vessels in Cape Cod Bay, 13 December - 15 May, 1999

Figure 11.
Sightings of right whales from aerial surveys in Cape Cod Bay, 1998 - 1999 Field Seasons

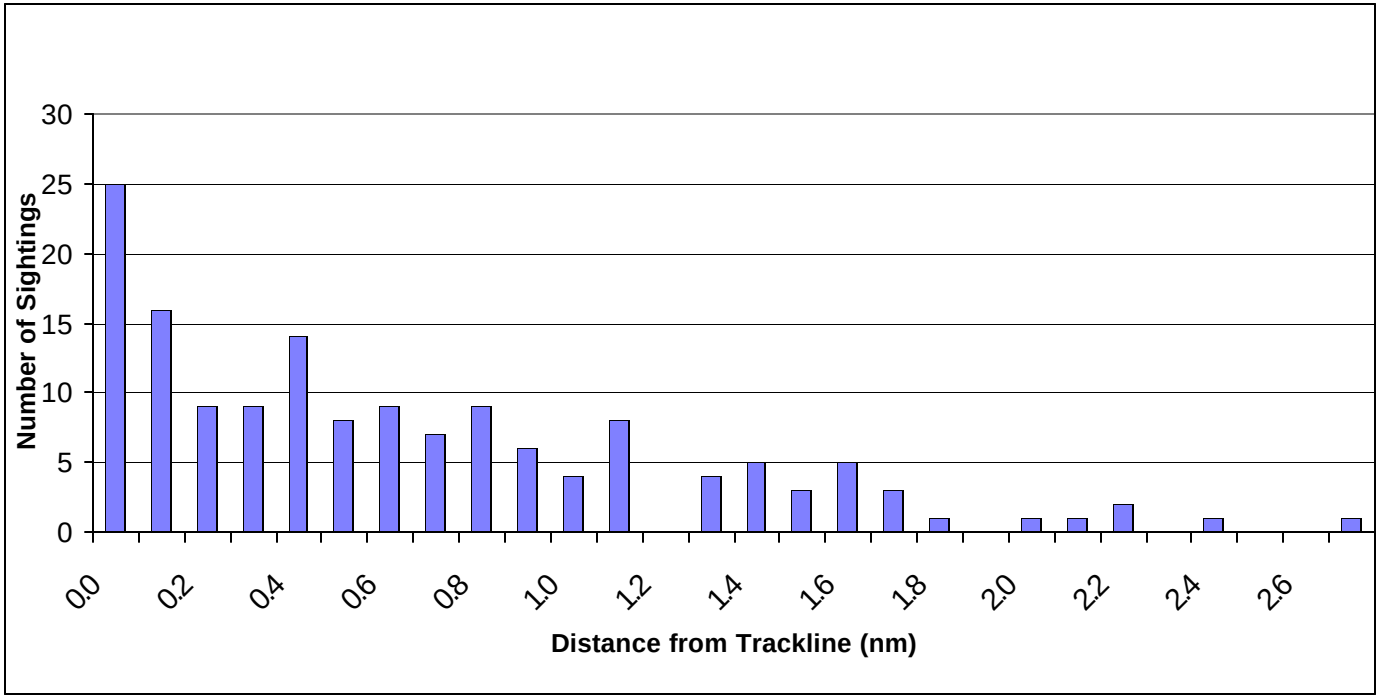


Full survey area.



Sightings recorded in Cape Cod Bay.

Figure 12: Perpendicular distance (in nautical miles, nm) from the trackline to right whales observed during aerial surveys in Cape Cod Bay, 1999.



Appendix I

Confirmed right whale identifications in Cape Cod Bay in 1998 and 1999 and the sighting histories of those 122 individuals. Abbreviations are listed below last sighting.

EGNO	Sex	Y1980	Y1981	Y1982	Y1983	Y1984	Y1985	Y1986	Y1987	Y1988	Y1989	Y1990	Y1991	Y1992	Y1993	Y1994	Y1995	Y1996	Y1997	Y1998
1004	F	OF					G		SMF		S	SFO			FS	S	M	S	SF	M
1014	F	MF		M	MOF					MGF	M	MS	SM				M	MS	M	M
1019	M	F		GB			MF	M	B	G			M		F		MF	MGF	M	MGN
1027	F	F		BF	BF	SA	MG	MGBF	B	MBF	SMF	B	B		MF	F	MF	MF	MGF	MF
1033	M		M	B			M	B	B	B					F	M	M	MF		M
1039	F	O						B			M	MS		M		M	M	SM	M	MF
1042	U	GB	G		B			M	GB	B	GB		B					M	MO	MN
1050	M	OG	G	G			G	B		G					F	F	F		F	GM
1102	M	B	GO	B				B	G	B	B	B	B		F	F	MF	MF	F	MF
1114	F		GF		B	F		GB	MB			SM	M	M	M	M	MFS	SMF	F	M
1121	M		GF	GB		MF			F	GF	GF	FB		F	F	MF	F	MFO	MF	M
1123	F		F			F		GF	GB	B	SF	B	F			F	F	MF	SF	F
1130	M	GF	GF	F		M		B	B	GB	BJO	MF	B		F	F	FB	SMGF	MF	MF
1131	M		GF	GF	GB	F	MG			B	F	F	B		F	F	F	MF	F	O
1133	M		GF		B	BF	MG		B	GB	B			F	MF		M	F	F	AF
1136	M		F	GF		F	G	B	B	GFB	B	F	MB	F	F	MFJ	F	MF	MF	F
1140	F		GF	F				M	SMGF	G		SMFJ				SMF	M	M	M	M
1146	M	B	GF		M	MBF			MF	MGB	MGBF			F	F	FJ	F	MF	F	M
1150	M	O	MF	B	M		MF	F	B	FB	F		MFB	F	F	MF	F	FO	MF	MF
1152	M		F	F	GJ	J	GF	M	GF	GF	GJF	F		F	SF	F	F	SFO	F	F
1158	F		F	F		MF		M	G	G	SGF	M	F	M	F	F	MF	S	MFS	SF
1162	M	B	F										B			F	F		F	M
1170	M		F	F	MF	MGF	F	M		GF	F	F	B	F	F	F	F	FO	MF	MAF
1208	F		M				MG		G	GS	SAG	N	S				S	SF		
1209	F	M		M	B			B	F	F	SB	S	M		F	FJ	F	F	F	MF
1239	M		G	F				B	GB	GB	GB		B	M	F	F	F	MFO	F	G
1240	F			F			F			G	SB	S	F		F	F	F	F	SF	M
1241	F			F	MF	MF	F	GF		JF	SF	F	MFB	M	F	FS	SF	M	MF	MOF
1245	F			F	MF	F	MFO	A	F	F	F	F		F	OFS	SF	FS	SAMF	F	M
1246	F			F		G		S			SGJF									
1249	M			OF	F	MG	M	MB	B	GB	B	B	BF		MF	F	MF	MFO	F	MF
1267	F			J	F			GBF	B	BF	GFB	FS	M		MF	MF	MF	SMF	MF	MF
1270	M	G		B		B				B	B	B								M
1271	M			B	B			MF		GB	B	B	B			F	F	OF	F	M
1280	U			GB		G	MB	MB	MB	B			M	M	M	M			M	M
1301	F				MF	AM		MB		BS	SF	M	B	BS		F	MF	MF	FS	S

1306	M				MF		F	G	M	GF	GF	B	B	F	F	F	F	SFO	F	F

Abbreviations: B-Browns Bank, F-Bay of Fundy, O-Gulf of Maine, G-Great South Channel, J-Jefferys Ledge, M-Cape Cod and Mass. Bays, A-Mid Atlantic, N-North, S-Southeast US.

Appendix I

Confirmed right whale identifications in Cape Cod Bay in 1998 and 1999 and the sighting histories of those 122 individuals. Abbreviations are listed below last sighting.

EGNO	Sex	Y1980	Y1981	Y1982	Y1983	Y1984	Y1985	Y1986	Y1987	Y1988	Y1989	Y1990	Y1991	Y1992	Y1993	Y1994	Y1995	Y1996	Y1997	Y1998
1310	F				GF		G	MF				FJ		O				M	S	M
1317	M				SM	MBJ		GB	B	M	SB		B			OF	F	F	MF	F
1327	M			MG	M	G	M	MBF	M	MB	B	B	GB	F	MF	F	F	FO	F	F
1328	U				G					B	F	B	G	MBF	F	F	M	M	F	
1405	F					SF	F			GF	F	F	F	F	F	F	F	SMF	SF	M
1406	F					SMF	MOF			MB	FA		MF	MF	MFA	SMF	MF	M	MF	MF
1407	F	B	G	M		SF				F	SMF				SOAF	F			M	M
1411	M					SF		G		B	MB	B	B		F		F	F	MF	M
1424	M		M		B	B	S	M	G	GB	GB	M	B	M	MF	F	F	SMF	F	MAF
1425	F			G		F	M		M	B	M	M		M	MFS	SGAF	MF	MF	F	A
1427	M					F	JM		GB	GB	B	B	B	MF	MF	F	MF	FO	MGF	FM
1428	M		G			MGO	M	GB		MG	F	FB	B	F	F	F	MF	SMF	F	M
1430	F					M	M	MB	MB	MG	B			SM	F	MF	MF	MNS	S	MGN
1503	F						F	M	M	MB		F		M	F	F	SFM	MF	BF	MG
1505	M						MF	AM		GOB	B	B	MF		MSF	FJ	MF	SMF	MF	MGF
1507	M						JOF	M	GMF	GOF	F	FB	MB	F	MF	F	F	MFO	MF	MGFJ
1509	F	GB				M	M	SM		B	SJM	M	M	SMJ		M	MN	MNS	SF	M
1513	U						M	B	GB	MG			MB					M	M	GM
1514	M						MG			MB	B	B	B				M			M
1601	F							SF	M	GF	F	F	MB		S	F	MF	F	SF	M
1602	F							SMF	MF	SMF	F		M	M	MFS	SF	MFS	SMFO	F	MF
1603	M							SGJMF	M		B	S	M		SF	F	MF	F	F	M
1606	M							MF	G	F	B				F	F	F	SMF	F	M
1608	F							SM	GM		F	F	MF	MF	F	F	MF	MFO	F	MF
1609	M							SM	F	F	F		B		F	F	F	SF		
1611	F							SM	SF	B	B		B			F	F	MFO	SF	MGF
1622	F							M	M	GBS	S	M	SM				F	MS	SMO	M
1701	F								F	F	B	B	FB		FS	F	FS	SF	OF	M
1703	F								F		F	F			SF	SF	F	SF	MF	
1704	F								SMGF	SMF	F	BM	MF	MF	MF	MF	MOF	MFOS	SMF	M
1706	F								SMF	F	F	F	F		SMF	FJ	SF	MF	MFS	MF
1708	M								GB	B	B			M	M			M	F	F
1709	M								M	JB	B	B	B	M	SF	F	F	F	F	SMF
1711	F								SM	GB	MB						F	SMF	F	M
1712	M								SAM		B	B	B			F	F	F	M	
1716	M								B	B	B		B		F	F	F	F	F	G

1802	F									MGF	MF	MF	MF	F	SMF	F	MF	MFS	F	MF

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EGNO	Sex	Y1980	Y1981	Y1982	Y1983	Y1984	Y1985	Y1986	Y1987	Y1988	Y1989	Y1990	Y1991	Y1992	Y1993	Y1994	Y1995	Y1996	Y1997	Y1998
1803	M									JF		F	F	S	SMF	F	F	M	OF	S
1804	M									GO	F	F	F	F	F	F	F	F	MF	SF
1812	F									B	B		B		SF	F	F	S	F	
1820	U									B	B	B	B		M	F		SMF	MF	M
1901	M										SGF		S	SF	SF	SF	SF	SMF	SMF	F
1909	F										SJM	MJ	B	M	SMF	F	SF	F	MF	MF
1911	F										F	M				F	MF	M	MF	MF
1934	F										SMO		B	M	SF	MF	MF	M	MF	MGF
1968	F										GF		B	B	S	F	F	OF	F	M
1981	U										F	F			S	F	F	SOF	FS	
2010	M											FJ	M	M	S	F	F	SF	MF	SM
2027	M											MJF			F	F	F	MFO	F	M
2048	M											F	F		F	F	MF	M	F	F
2050	F											M		M	SM		MF	SMF	MF	MGF
2114	F											S	SB		M	F	MF		F	M
2123	F												F	MF	SF	FS	FS	SMFO	SMF	SMAF
2135	M												MF	MF	SF	F	F	SMOF	GF	M
2140	M											S	F	F	S	MF	F	SMF	F	MF
2145	F												MF	F	MF	F	F	MOF	M	MF
2158	M												F	MF	F	F	MF	MF		SM
2201	M													SF	SMF	F	MF	SFO	F	SF
2209	M													SMJ	M	F	MF	SMFO	F	AF
2215	M													SB	MF	F	MF	SMFO	MF	SMF
2223	F													F	F	F	F	O	F	MGF
2240	F													SF	SF	F	F	SFO	F	MG
2271	M													SF	F	F	F	SMOF	F	M
2303	M														SF	SMF	MF	SF	M	SAF
2304	M														M	F	F	MF	F	F
2340	M														F	F	M	F	F	
2350	U														F	F	MF		F	
2406	U														A	SMF	M	F	F	MF
2425	F															SGAF	MF			M
2427	M															M	F	MFO	F	F
2430	F															F	MF	F	F	F
2470	U															F	F	MF	F	M
2479	U															F	F	MF	MF	MF

2503	F																SFM	F	F	MF

Abbreviations: B-Browns Bank, F-Bay of Fundy, O-Gulf of Maine, G-Great South Channel, J-Jefferys Ledge, M-Cape Cod and Mass. Bays, A-Mid Atlantic, N-North, S-Southeast US.

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EGNO	Sex	Y1980	Y1981	Y1982	Y1983	Y1984	Y1985	Y1986	Y1987	Y1988	Y1989	Y1990	Y1991	Y1992	Y1993	Y1994	Y1995	Y1996	Y1997	Y1998
2614	F																	SMF		M
2635	U																	SMF		
2645	F																	SAMF	SMF	F
2705	U																		SF	SMF
2710	U																	S	SF	F
2740	M																		SF	F
2750	M																		SF	F
99-5	U																		F	GF
99-42	U																			
99-183	U																			
98-50	U																	F	F	GM

Abbreviations: B-Browns Bank, F-Bay of Fundy, O-Gulf of Maine, G-Great South Channel, J-Jefferys Ledge, M-Cape Cod and Mass. Bays, A-Mid Atlantic, N-North, S-Southeast US.

Appendix II.

Sighting records (n=91) of right whales identified in Cape Cod Bay and adjacent waters in December 1998 and January - mid May, 1999. F (female), M (male), A (adult) and J (Juvenile), U (unknown).

Id #	Sex	Age	13-Dec	6-Jan	8-Jan	17-Jan	21-Jan	22-Jan	26-Jan	27-Jan	1-Feb	2-Feb	9-Feb	15-Feb	16-Feb	17-Feb	24-Feb	28-Feb	3-Mar	10-Mar	14-Mar	21-Mar	25-Mar	26-Mar	31-Mar	1-Apr	3-Apr	6-Apr	9-Apr	11-Apr	15-Apr	19-Apr	20-Apr	21-Apr	25-Apr	28-Apr	1-May	2-May	11-May	12-May	15-May	23-May
2705	U	2	x																																					
2614	F	3	x																																					
1507	M	14	x																				x							x	x			x					
2406	U	5	x																				x	x					x								x		
99-5	U	U	x																			x		x			x	x	x	x	x	x	x						
1424	M	A			x				x	x																													
1170	M	18			x					x																													
1406	F	15			x		x	x		x							x		x				x			x				x									
1716	M	A			x				x	x		x	x		x																								
1608	F	13			x							x			x						x	x		x		x	x	x	x	x	x	x	x	x					x
1014	F	A				x					x								x	x	x	x						x			x		x*						
2479	U	5					x		x							x																							
1301	F	16					x			x							x		x																				
2145	F	8					x								x									x	x	x	x												
2010	M	9					x	x							x		x										x										x		
99-42	U	U					x		x	x	x												x	x		x		x		x	x	x	x			x			
2271	M	7					x																																
1405	F	15					x																																
2135	M	8					x		x																														
1136	M	A						x		x	x															x													
1158	F	A							x		x	x							x																				x
1803	M	11							x	x		x			x				x																				
1019	M	A							x																														
1208	F	A							x																														
1611	F	13							x																														
2303	M	6								x							x		x																				
1509	F	A								x	x											x			x	x			x		x								
1140	F	A								x		x							x																				
1701	F	12								x		x			x																								
2470	U	U									x				x		x																						
1027	F	A									x				x	x			x																				
1267	F	17										x																											
2425	F	5												x					x			x				x	x	x				x	x	x		x			
2215	M	7												x	x			x	x																			x	
1150	M	A													x									x															
1911	F	10													x				x		x							x	x	x	x	x	x		x				
2201	M	7													x																								
1812	F	A														x					x	x						x	x										
2123	F	8														x			x				x				x	x		x									
1430	F	14														x																							
2750	M	2															x		x					x		x			x	x	x		x	x					
99-183	U	U															x					x				x	x	x	x		x	x	x	x	x				x
1503	F	14																x						x		x		x		x									
2340	M	U																x																					
1425	F	A																x																					
1603	M	13																	x																				
2050	F	A																	x					x					x	x									
2645	F	3																	x	x		x	x			x	x	x		x	x		x	x	x		x	x	
1704	F	12																	x		x																		
1981	U	10																	x																				
1802	F	11																	x																				
2048	M	9																	x							x				x									
2140	M	8																	x	x																			
1606	M	13																	x																				
1820	U	A																	x																				
2158	M	8																		x	x																		
1712	M	12																		x	x			x		x													
2635	U	3																		x																			
2740	M	2																			x	x									x	x	x	x	x				
1130	M	A																			x																		
2350	U	U																			x																		
1711	F	12																			x			x		x													
1317	M	16																			x	x				x													
1909	F	10																			x																		
1968	F	10																			x										x								
1804	M	11														x																							
2427	M	5														x						x				x													
2430	F	U																					x																
1328	U	A																						x															
1622	F	A																			x					x													
1131	M	A																								x			x										
2223	F	7																								x			x	x		x		x	x				
1427	M	15																								x			x			x	x	x	x				
1934	F	10																								x			x	x		x	x	x	x				
2304	M	6																									x		x						x	x	x			
1239	M	18																											x										
2710	U	2																											x			x	x	x					
1901	M	10																											x										x
2209	M	7																											x										
1240	F	A																											x										
1708	M	12																											x		x								
																														1609	M	13							
																														98-50	U	U							

Totals	91	5	0	5	1	9	3	10	12	7	7	1	2	12	5	7	4	23	6	14	12	8	11	5	19	6	23	18	16	20	12	15	11	14	2	3	1	5	0	0	4

Appendices III, IV and V are not printed with the electronic version of this report, but may be obtained by contacting Daniel McKiernan at the Massachusetts Division of Marine Fisheries.